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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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See Advertisement page 20. 5701

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See Advertisement page 38, July 6. 5402

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MINISTRY OF MUNITIONS OF WAR.
Whitehall Place, S.W. 1.
26th June, 1917.

ORDER.

STEAM DRIVEN HIGHWAY LORRIES AND TRAILERS.

The Minister of Munitions, in exercise of the powers conferred upon him by the Defence of the Realm (Consolidation) Act, 1914, the Defence of the Realm (Amendment) No. 2, Act, 1915, the Defence of the Realm Regulations, the Munitions of War Acts, 1915 and 1916, and all other powers thereunto enabling him, HEREBY ORDERS that all persons (other than Railway Companies) owning or having in their possession or under their control any Steam Driven Highway Lorries or Trailers in Great Britain, shall, within Fourteen Days from the date thereof, send in to the Deputy Director-General of Railway Material Licences, Ministry of Munitions, Whitehall Place, London, S.W. 1, Returns containing the particulars with regard to such Steam Lorries and Trailers in the form set out in the tabular statement below, and to make such further Return concerning any such Steam Lorries and Trailers as may hereafter be required by the Deputy Director-General of Railway Material Licences.

TABULAR STATEMENT OF RETURN OF

..... Steam Lorries.

..... Trailers.

A Registered Letters and Numbers.
B Owner's Name and Full Address.
C Maker of the Lorry.
D Date on which they were built.
E Working Pressure on Boiler, lb. sq. in.
F Whether Steam Boiler is fired with coal, coke or oil fuel.
G Name of Insurance Co. for the Boiler.
H Net carrying capacity of Lorry in tons.
Net carrying capacity of Trailer in tons.
I Weight of Lorry unloaded.
Weight of Trailer unloaded.
J Is the Lorry a normal or of a special type?
K General condition of the Lorry and Mechanism.
L Work (if any) on which the Lorry and/or Trailer is usually employed.

Signed .....

Address.....

Date .....

NOTE.—No separate official form is being issued for the purposes of the above Return. H 340

University of Birmingham.

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Secretary.

UNIVERSITY OF DURHAM.

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PRINCIPAL—W. H. HADOW, M.A., D.Mus., J.P.

SESSION 1917-18.
COMMENCING 24th SEPTEMBER, 1917.

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For Particulars of Course of INSTRUCTION by CORRESPONDENCE, write to "THE WESTMINSTER ENGINEERING BUREAU," 32, Old Oak Road, Acton Park, London, W. 5028

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APPOINTMENTS OPEN.

PORT-OF-SPAIN CITY COUNCIL.

POST OF CITY ENGINEER.

The Port-of-Spain City Council invite

Applications for the Post of CITY ENGINEER, and ENGINEER OF WATER AND SEWERAGE WORKS, with which is associated also the general supervision of the management of the Woodbrooke Estate and the Cocorite Farm.

2. The salary attached to the post is £800 a year, rising by annual increments of £25 a year to a maximum of £750; with an allowance of £75 a year, towards the upkeep of a motor vehicle for the performance of his duties.

3. The appointment is subject to the approval of the Governor.

4. The office is pensionable under the Port-of-Spain Corporation Ordinance, 1914.

5. Salary will commence from the date of arrival in Trinidad. No allowance is made in respect of passage.

6. Candidates must submit evidence of their being corporate members of the Institution of Civil Engineers of England, and of possessing experience in the designing, construction and maintenance of waterworks and sewerage systems.

7. Should the officer be desirous of leaving the service of the Corporation within five years from the date of his appointment, the Council reserve to themselves the right to exact not less than three months' notice in writing.

8. The Engineer will be required to reside within the City or within a mile of the City, and to devote his whole time to the service of the Corporation.

9. The successful candidate will be required, within one month of the date of his arrival in the Colony, to furnish a bond, with an approved surety, or to enter into a bond with an approved guarantee society, in the sum of £500 for the due performance of the duties of the office.

10. The successful candidate must be prepared to take up the duties of his office within three months of the date of his receiving the official intimation from the Town Clerk that his appointment has been approved by the Governor.

11. Applications, accompanied by not more than two recent testimonials (one of which should be from the candidate's present employers), and stating age and previous experience, together with a medical certificate that the candidate is fit for service in the West Indies, must reach the Town Clerk, Port-of-Spain, Trinidad, not later than the 1st December, 1917.

PHILIP H. SALOMON,
Acting Town Clerk.

Town Hall,
Port-of-Spain,
Trinidad, B.W.I. H 119

SOUTH WALES AND MONMOUTHSHIRE SCHOOL OF MINES.

Wanted, for the Duration of the War, a SENIOR LECTURER in MECHANICAL ENGINEERING and MATHEMATICS to act temporarily as Head of the Mechanical Engineering Department.
Applicants must have had workshop experience and a knowledge of mining engineering practice and must be capable of conducting testing work.
Also SENIOR LECTURER in CHEMISTRY and PHYSICS to act temporarily as Head of the Chemistry Department.
Applicants must have had works experience and a knowledge of mining chemical practice, and must be capable of conducting testing work.
Only candidates ineligible for military service need apply.
Salary according to qualifications and experience.
For further particulars apply to—
THE PRINCIPAL,
Treforest, H 228
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The Services of a Lecturer in MECHANICAL and ELECTRICAL ENGINEERING and a LECTURER in CHEMISTRY are REQUIRED.
Commencing salary in each case, £200 per annum. Duties commence in September. Further information may be obtained from the Principal, to whom applications must be returned by August 4th.
JOHN J. JACKSON,
Director of Education,
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Works Manager Required in Government Controlled Works, London District, preferably with Electrical experience. Must be of proved ability to organise and control all departments on progressive lines, and should have thorough modern machine shop experience. Good prospects and permanency to suitable man. All applications will be treated in strictest confidence.—Write fully to H 353, Offices of ENGINEERING.

Chief Engineer Required for large Aero Engine Works, London district, 2000 hands employed. Salary, £1000 p.a.—Address, stating experience, H 343, Offices of ENGINEERING.

Electrical Engineer.—Wanted, Competent Electrical ENGINEER, able to take charge of the installation of generators, switchboard and all electrical appliances in large electric power station. Energetic men only need apply. Salary, £6. Must be ineligible for military service. —Address, H 350, Offices of ENGINEERING.

Assistant Engineer, experienced in Blast Furnace and Steel Works Plant, WANTED for Steel Works in South Wales under Government control. Must be Six o'clock a.m. man. Ineligible for military service, and not already engaged on Government work.—Apply, stating age, qualifications, and salary required, to your nearest EMPLOYMENT EXCHANGE, quoting No. A 3439. H 208

Good Sewerage and Water ENGINEER WANTED, to take charge of a number of installations. Good man will be liberally dealt with.—State full particulars of experience, &c 7052, WILLIAMS' Advertisement Offices, Bradford. H 367

Wanted, First-class Engineering CLERK of WORKS, competent to undertake control over the erection of all machinery, boilers, pipe-work, &c., for large electric power station. Must be competent to inspect and test plant, conversant with the latest engineering practice, methodical and energetic. Salary, £285 per year, with war bonus £15.—Address, H 348, Offices of ENGINEERING.

Wanted, Assistant Engineering CLERK of WORKS, well up in electric power station designs, competent to inspect and test plant; energetic man only need apply. Salary £5 per week. Must be ineligible for military service.—Address, H 349, Offices of ENGINEERING.

Production Engineer and PROGRESS CLERK WANTED, a competent man accustomed to supervising the progress and rapid production of aeroplane engines in process of manufacture in works employing 1500 hands. Apply, stating experience and salary, to your nearest EMPLOYMENT EXCHANGE, quoting No. A 3445. No person already on Government work will be engaged. H 301

Chief Rate Fixer Required by firm manufacturing Internal Combustion Engines and Motor Cars. Must be capable of laying out processes, fixing rates and estimating to drawings, on approved modern methods; good organiser essential; take entire charge department. Only men of tried experience, strong character and possessed of considerable tact need apply. Excellent prospects and generous salary to right man.—Address, H 286, Offices of ENGINEERING.

Wanted, Immediately, for a large Midland establishment, a fully experienced HEAD RATE-FIXER, accustomed to details of internal combustion engines. A good salary will be paid to the right man. No person already on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE, quoting No. A3429. H 310

Wanted, a Good Practical MAN as RATE FIXER in a large Crane Works, North of England. No person employed upon Government work will be engaged.—Apply, stating experience and salary, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and H 371.

First-class Experienced ESTIMATOR WANTED by Government controlled works making large and small engines, repetition and general work; man with thorough practical knowledge of machining, fitting and foundries, &c., who could organise and control a department dealing with rate-fixing, progress and demonstration. Only men thoroughly experienced need apply. Permanent position to suitable man. State age, experience and salary required. No one already employed on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and H 39.

Wanted, First-class Engineer to take charge of large Dyeworks. Good salary will be paid to a competent man; no other need apply. Must be over military age.—Address, stating age and full particulars of experience, 7055, WILLIAMS' Advertisement Offices, Bradford. H 366

The Rhondda Engineering AND MINING COMPANY, LIMITED, Cambrian Buildings, Cardiff, and their affiliated Company, SHEPPARD & SONS, LTD., Ironfounders and Engineers, Bridgend, who are engaged upon work of National importance, REQUIRE the SERVICES of a Competent ENGINEER to act as Commercial and General Manager for both concerns.
Applicants must have had commercial and workshop experience, preferably in connection with the sale and manufacture of colliery plants, particularly for treatment of coal.
Applications should be addressed to the SECRETARY, THE RHONDDA ENGINEERING AND MINING CO., LTD., Cambrian Buildings, Cardiff, giving full particulars of age, experience and salary required, accompanied by testimonials and references. H 312

Required, a thoroughly qualified Manufacturing ENGINEER, to assist in the management and control of 1000 to 1500 hands engaged in the production of aeroplane engines. Give full particulars of experience and salary required to your nearest EMPLOYMENT EXCHANGE, quoting No. A 3444. No person already on Government work will be engaged. H 309

Assistant Superintendent WANTED in large engineering works, employed solely on direct Government contracts. The job is permanent and will continue after the war. A capable and energetic man experienced in repetition work will find ample opportunities for advancement.—Address, stating age, experience, and salary to H 342, Offices of ENGINEERING.

Drawing Office, Order and MATERIAL CLERK WANTED; preference given to one having experience in Locomotive and Light Railway work, also Estimating (he would be required to deal with all shop orders and material). Only competent, experienced men need apply, and no person already on Government work will be engaged.—State experience, age, and salary required to your nearest EMPLOYMENT EXCHANGE, quoting No. A 3459. H 341

Draughtsman (Mechanical), one used to Jig and Toolwork preferred, WANTED by Midland firm manufacturing ball and roller bearings for aircraft and mechanical transport. Good salary according to experience. No man already on Government work can be engaged.—Application in the first instance should be made to your nearest EMPLOYMENT EXCHANGE, mentioning this Paper and No. A3390. H 217

Draughtsman Wanted, thoroughly capable, for large blast furnace and steel works plant. State age, experience, salary required, and when at liberty. No one already employed on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, quoting No. A 3295. G 966

Draughtsman Experienced in internal combustion engines REQUIRED for Admiralty Establishment. Preference given to one having knowledge of heavy oil engines.—State age, salary required, details of previous experience, with approximate periods employed at each firm and position, to BOX No. 1170, care of Messrs. R. F. WHITE & SON, Genl. Advg. Agents, 33, Fleet Street, London, E.C.4. H 275

Chief Draughtsman.—Wanted, thoroughly capable MAN, with general engineering experience. Must be good organiser, well up in modern workshop methods, and able to exercise efficient control over about 30 or 40 draughtsmen. Liberal salary to suitable man. No person already engaged on Government work will be employed.—Address in confidence, stating fully experience, positions held, and age, H 276, Offices of ENGINEERING.

Required, for Steelworks Furnace Design and Charging Machinery, several DRAUGHTSMEN. Good salaries to suitable men. No one already on Government work need apply.—Reply, stating age, experience and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and H 336.

A Young Draughtsman REQUIRED who has had shop experience; preference given to one accustomed to piping and general plant work. State age, experience and salary required. No one already employed on Government work will be engaged.—Apply, nearest EMPLOYMENT EXCHANGE, mentioning this Journal and H 337.

Draughtsman Wanted at Once for Government Controlled Establishment. If possible with some experience of aeroplane design. No one already employed on Government work will be engaged.—Applicants to state age, experience and salary required through nearest EMPLOYMENT EXCHANGE, mentioning this Journal and H 335.

Quantity Draughtsman or CLERK REQUIRED immediately for Government Controlled Establishment, with knowledge of engineering drawings and practice. Must be over military age or exempt from service. No one already employed on Government work will be engaged. Application to be made through nearest EMPLOYMENT EXCHANGE. State age, experience and salary required, mentioning this Journal and H 334.

Draughtsman. — Wanted, first-class MECHANICAL DRAUGHTSMAN, thoroughly conversant with steam and water pipework; also with the lay-out of electricity generating plant. Must be ineligible for military service.—Address, stating salary required, H 332, Offices of ENGINEERING.

Draughtsmen Required Immediately for important Admiralty Establishment. Applicants must be neat and quick, also well up in small details.—Give full particulars of experience, copies of recent testimonials, state salary required, age and present salary, by letter only, to BOX, No. 1174, care of Messrs. R. F. WHITE & SONS, Genl. Advng. Agents, 33, Fleet Street, E.C. 4. H 345

Draughtsmen Required Immediately, with knowledge of ropeway work preferred (munition and war work only). No one employed on Government work or resident more than 10 miles away will be engaged.—Address, stating age, previous experience, salary required, &c., H 347, Offices of ENGINEERING.

Draughtsmen Required, used to motor work and internal combustion engines. Permanency for suitable applicants. No person employed on Government work need apply. —State experience, age and wages required, to your nearest EMPLOYMENT EXCHANGE, quoting No. A 3476. H 374

Draughtsman Required, for first-class Automobile work. State age, experience and salary required. No person already engaged on Government work will be considered.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and H 376.

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DUCTILE MATERIALS UNDER VARIABLE SHEAR STRESS.

Behaviour of Ductile Materials under Variable Shear Stress, with Special Reference to Shafts subjected to Bending and Twisting.

By R. W. BAILEY, Wh.Sch.

MUCH research remains to be executed before our knowledge of the behaviour of materials under compound stresses of a varying character can be regarded as in a satisfactory state. Until comparatively recently most investigations have been concerned with unvarying or static stresses, the results of which, while valuable when employed in cases where the straining action does not fluctuate, have been of very little assistance in controlling the design of parts such as shafts, where, generally, the straining action is variable. In regard to the latter it may be said that it is not of much practical consequence whether the Guest or Rankine formula be employed, provided the designer uses a stress which experience shows is satisfactory for the case he has to deal with. For with both of these formulæ the working stress needs to be altered as the straining action changes from, say, a steady twisting moment, through a range of combined bending and twisting moments, to the other extreme of a reversing bending moment; and, so far, there is very little to guide the designer, except his experience, in selecting a stress to meet any given combination of bending and twisting moments.

It is in the direction of providing information respecting permissible stresses in such cases that a large field for experimental research exists.

In the absence of experimental data of the kind required, speculation based upon the information available will serve to some extent as a guide to the designer, and also may suggest some path along which practical investigation might proceed with advantage. It is the purpose of the present article, therefore, with this object in view, to adopt what appears to be a rational hypothesis in regard to the breakdown of ductile materials under varying stresses, and upon it as a basis to deduce the strength of shafts subjected to combined bending and twisting of a varying character.

It is now fairly generally accepted that ductile materials fail by shear when subjected to static stresses, as pointed out by Mr. J. J. Guest—at any rate this is so for a wide range of the ratio of the constituent direct and shear stresses, such as are set up, for example, by static bending and twisting moments applied to a shaft. And in the case where the bending and twisting moments are reversing in synchronism, the recent investigations by Dr. T. E. Stanton and Mr. R. G. Batson, and by Dr. W. Mason (see ENGINEERING, September 15, 1916; February 23, 1917; and March 2, 1917) support the view that here also the maximum shear stress determines the breakdown. In the latter case the maximum shear stress which may be applied an unlimited number of times is, of course, much less than the ultimate static shear strength of the material; and, obviously, it may be assumed that in cases where the straining action is variable, but intermediate between the static and reversing cases, that if failure is by shear, then the limiting fatigue shear stress (*i.e.*, the maximum shear stress of the given degree of variation which can be applied indefinitely) will be intermediate in magnitude between the static and reversing values. Stanton and Batson's results, as will be seen on reference to Table I, appear to show that the normal stress on the plane of maximum shear stress has no appreciable effect on the failure by shear, and in this additional respect, therefore, the behaviour of a material under a reversing straining action is similar to the static case. In the absence of evidence to the contrary, then, the most reasonable assumption to make in pursuing the object in view is that under all combinations of bending moment and twisting moment, either variable or constant in magnitude, the failure of a ductile material is by shear, uninfluenced by the presence of normal stresses on the plane of failure. The question now arises, what shear stress causes failure? Is it the maximum shear stress, or may it have some other value?

TABLE I.

Ratio of bending moment to twisting moment $\left(\frac{B}{T}\right)$ ..	∞	0.820	0.667	0.546	0
Maximum shear stress* lb. per sq. in.	±12,500	±10,500	±10,400	±11,800	±12,600
Normal stress on plane of maximum shear stress† lb. per sq. in.	±12,500	±17,150	±15,250	±15,770	0

* Given by Stanton and Batson.
† Calculated by writer from Stanton and Batson's data.

The hypothesis proposed is, briefly, that a ductile material fails by shear on the plane at which the shear stress has its most destructive value. In the case of materials subjected to either static or varying tension, compression, torsion, and bending, or to combined bending and torsion, either static in character or varying in such a way that the bending moment and the twisting moment vary synchronously and reach their maximum and minimum values together, the most destructive shear stress is the maximum shear stress; but in the case of shafts under practical conditions, where, most commonly, the straining action consists of a reversing bending moment and a twisting moment either constant in value or nearly so, the proposed hypothesis leads to the conclusion that the most destructive shear stress is not the maximum shear stress. In order to reach this conclusion, however, it is necessary first to consider how the limiting fatigue shear stress of ductile steel is related to the range of stress variation and the static shear strength of the material.

There is a paucity of information bearing upon the breakdown of materials under a varying or alternating twisting moment, from which might be obtained a relation of the kind required. However, if materials subjected to static or reversing straining actions break down by shear uninfluenced by the presence of normal stress, as appears to be the case, then the cause of failure in torsion and direct stress tests is the same, and hence the results obtained by Wohler and others* in tests of materials under varying direct stress offer guidance in the case of torsion. From this point of view it is significant that in Wohler's torsion and direct stress tests on the same material (axle steel), the ratio of the limiting fatigue stresses for variation of the straining action between zero and a maximum value and for complete reversal is practically the same in the two cases, being approximately 2. The inference is that the cause of failure is likely to be similar in torsion and direct stress tests when the straining action ranges between zero and a maximum value, and hereby a measure of support is given to the assumptions made regarding the mode of failure over the whole range of straining action. A formula applicable to the case of shear stress, then, might be constructed by modifying one of the well-known formulæ which fit the case of direct stresses, such as Gerber's, or that due to Launhardt and Weyrauch, by making alterations in accord with published data relating to the ratio of the strength of ductile materials under shear and direct stresses. While such a formula would be useful, provided it be limited in its application to cases where the fatigue stress does not greatly exceed the elastic limit of the material, it would be unsuitable for cases where the stress approaches the static condition; largely owing, of course, to the considerable divergence which obtains in regard to the actual magnitude and distribution of the stresses and their "calculated" values when breakdown by tension and by torsion takes place. For this reason it is more desirable, having regard to the fact that results of general application are sought, to construct a suitable formula for shear stress which will fit the three cases:—(*a*) Static shear stress, as calculated from torsion tests on the assumption that the stress at any point is proportional to the distance of the point from the axis of torsion; (*b*) limiting fatigue shear stress varying between zero and a maximum; (*c*) limiting fatigue shear stress completely reversing. Such a formula would be assumed to apply over the whole range of stress from case (*a*) to case (*c*). A simple formula which may be made to represent the cases (*a*), (*b*) and (*c*), and the intervening ranges, is the following:—

$$f = f_0(a + b\gamma + c\gamma^2) \quad . \quad . \quad . \quad (1)$$

where

f_0 = static shear stress.
f = limiting fatigue stress.
γ = ratio: $\frac{\text{minimum shear stress}}{\text{maximum shear stress}}$
a, b and c are constants.

It will be noted that the formula corresponds in its object to the Launhardt-Weyrauch formula for direct stresses.

A consideration of Wohler's torsion tests upon axle steel and Stanton and Batson's data suggests, as a rough working basis, sufficiently correct, however, for most practical purposes, that the ratio of the calculated static stress f_0 to the limiting fatigue stress for complete reversal is about 4.5 and 4 in the case of mild steel and the higher tensile steels used for shafts, respectively. If these ratios are adopted, and if it is assumed that the stress for case (*b*) is twice that for case (*c*), equation (1) produces equations (2) and (3) for the cases of mild and higher tensile steels, respectively:

$$f = \frac{f_0}{9}(4 + 3.5\gamma + 1.5\gamma^2) \quad . \quad . \quad (2)$$

$$f = \frac{f_0}{8}(4 + 3\gamma + \gamma^2). \quad . \quad . \quad . \quad (3)$$

The method adopted in this investigation will now be understood. Suppose a shaft to be subjected to a bending moment and a twisting moment, each varying in a known manner. The maximum and minimum values of the shear stress on any plane in the material can be ascertained in the ordinary way, and by means of equation (2) or (3) the static stress of equal destructiveness can be calculated. The plane at which this equivalent static stress reaches its maximum value will be the plane of failure; and it will be observed that if the straining action has its largest value for unlimited repetition, the equivalent static stress on this plane will be equal to f_0. Finally, the results obtained in this manner may be presented in such a form as to be readily available for practical purposes in connection with the Guest formula—which is the most rational as well as the most convenient formula for the purpose.

The most common straining action met with in practice consists of a completely reversing bending moment combined with a varying twisting moment, and this case will now be considered. Other cases can be treated similarly, and therefore no attention need be paid to them now.

B = Maximum bending moment in pound or ton inches.
T = " twisting " " " "
δT = Variation of " " " " "
q = Maximum tensile or compressive stress due to B in pounds or tons per square inch.
$= \frac{32\,B}{\pi D^3}$ for solid shafts, and $\frac{32\,BD}{\pi(D^4 - d^4)}$ for hollow shafts where D and d are the external and internal diameters of the shaft.
f = Maximum value of the shear stress due to T in pounds or tons per square inch.
$= \frac{16\,T}{\pi D^3}$ for solid shafts, and $\frac{16\,TD}{\pi(D^4 - d^4)}$ for hollow shafts.
δf = Variation of f due to δT.
$= \frac{16\,\delta T}{\pi D^3}$ for solid shafts, and $\frac{16\,\delta TD}{\pi(D^4 - d^4)}$ for hollow shafts.

At any given instant let
q_1 = Maximum tensile or compressive stress due to the bending moment.
f_1 = Maximum shear stress due to the twisting moment.

Consider now an elementary triangular lamina A B C (Fig. 1, page 82) in the skin of the shaft, having the edge A B in the plane of torsion, the edge B C at right angles to A B (*i.e.*, parallel to the axis of shaft), and the edge A C inclined at any angle θ to A B. Let the shear stress f_1 and the direct stress q_1 act upon the planes A B and B C in the manner shown; and let f' be the corresponding shear stress acting on the plane A C. (The normal stress acting on A C is omitted in the figure.) Then it is easy to show that

$$f' = f_1 \cos 2\theta - \frac{q_1}{2} \sin 2\theta \quad . \quad . \quad (4)$$

Now f' is a varying shear stress whose maximum

* "The Testing of Materials of Construction" (Unwin).

value and range of variation will depend not only upon the values of $q f$, and δf, but also upon the relative variation of q_1 and f_1. The most dangerous case occurs when the maximum twisting moment synchronises with the maximum bending moment, and the minimum twisting moment is applied when the bending moment is completely reversed. In most cases the conditions will not be quite so severe as this. However, it is advisable to proceed with this case, and thereby, in applying the results, throw any errors on the side of safety. Under these circumstances the maximum value of f' is

$$f' \text{ (max.)} = f \cos 2\theta + \frac{q}{2} \sin 2\theta \quad . \quad . \quad (5)$$

and the minimum value of f' is

$$f' \text{ (min.)} = f(1-\delta)\cos 2\theta - \frac{q}{2}\sin 2\theta \quad . \quad (6)$$

The ratio of (6) to (5) is the ratio γ entering in (1), (2) and (3), whence for the plane A C

$$\gamma = \frac{f(1-\delta)\cos 2\theta - \frac{q}{2}\sin 2\theta}{f\cos 2\theta + \frac{q}{2}\sin 2\theta} \quad . \quad . \quad (7)$$

The dynamic stress f' will be equivalent in destructiveness to a certain static shear stress f_0' which, from (1), is given in a general form by

$$f_0' = \frac{f' \text{ (max.)}}{a + b\gamma + c\gamma^2} \quad . \quad . \quad . \quad (8)$$

In other words, f_0' will have the same factor of safety in reference to the static shear strength of the material as f' (max.) has to its similarly varying limiting fatigue stress. For the purpose of this article, and in most practical cases, it is sufficiently accurate to employ one formula to represent the relation between f_0' and f' (max.) for all steels. Equation (3) will be very suitable for the purpose. Using (3), putting f' (max.) for f, and f_0' for f_0, and introducing the values of f' (max.) and γ given by (5) and (7) gives

$$f_0' = \frac{8f(\cos 2\theta + \frac{q}{2f}\sin 2\theta)^3}{(8 - 5\delta + \delta^2)\cos^2 2\theta + (6-\delta)\frac{q}{2f}\sin 2\theta\cos 2\theta + 2\left(\frac{q}{2f}\right)^2 \sin^2 2\theta.} \quad . \quad (9)$$

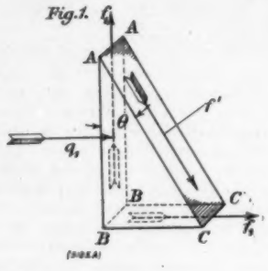
According to the hypothesis that breakdown is determined by the most destructive shear stress, failure is most likely to occur on a plane A C upon which f_0' has its maximum value. The angle of inclination ϕ of this plane with the plane of torsion A B is determined by $\frac{df_0'}{d\theta} = 0$, ϕ being the value of θ for a maximum f_0'. Differentiation of (9) and equation to zero leads to the following equation for ϕ, viz. :

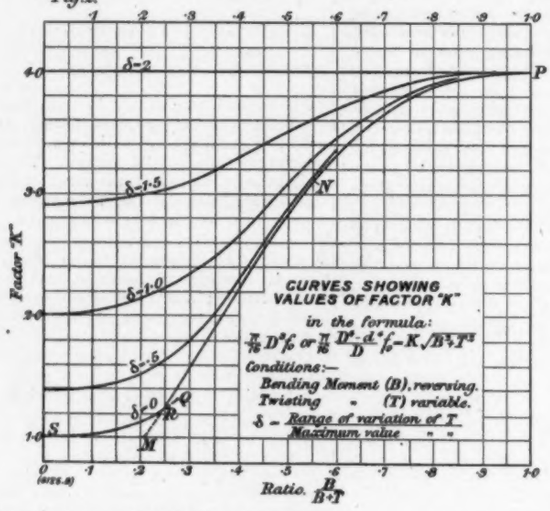
$$\tan^2 2\phi - \frac{1}{\delta}\left[\frac{q}{f} + \frac{2f}{q}(4 - 8\delta + 2\delta^2)\right]\tan^2 2\phi - \frac{2}{\delta}\left[4 - \delta - 2(8 - 5\delta + \delta^2)\left(\frac{f}{q}\right)^2\right]\tan 2\phi - \frac{2}{\delta}(18 - 14\delta + 3\delta^2)\frac{f}{q} = 0 \quad . \quad . \quad (10)$$

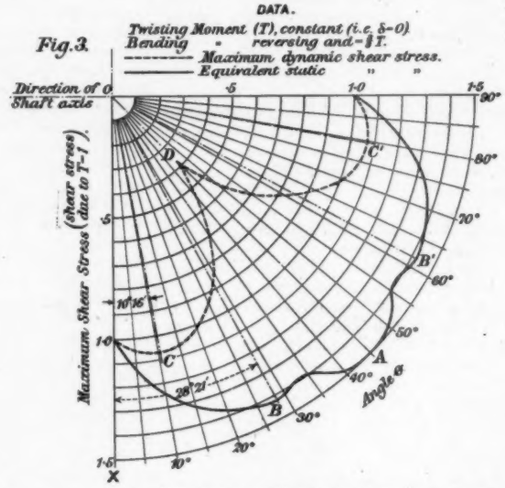
The maximum value f_0 of f_0' may be obtained in any given case from (9) by introducing in place of θ the value of ϕ given by (10). It is more convenient, however, to modify the form of the equation. If the numerator and denominator of (9) are multiplied by

$$\sqrt{f^2 + \frac{q^2}{4}},$$

and ϕ is introduced in place of θ, the value of f_0 is given by







$$f_0 = \left(\sqrt{f^2 + \frac{q^2}{4}}\right)\frac{8}{\sqrt{1 + \left(\frac{q}{2f}\right)^2}} \times \frac{\left(\cos 2\phi + \frac{q}{2f}\sin 2\phi\right)^3}{(8 - 5\delta + \delta^2)\cos^2 2\phi + (6-\delta)\frac{q}{2f}\sin 2\phi\cos 2\phi + 2\left(\frac{q}{2f}\right)^2 \sin^2 2\phi} \quad (11)$$

It is not difficult to show that

$$\sqrt{f_2 + \frac{q^2}{4}} = \frac{16}{\pi D^3}\sqrt{B^2 + T^2} \text{ for solid shafts}$$

$$= \frac{16\,D}{\pi(D^4 - d^4)}\sqrt{B^2 + T^2} \text{ for hollow shafts}$$

and

$$\frac{q}{2f} = \frac{B}{T} \text{ for both solid and hollow shafts.}$$

Introduction of these values in (11) leads to the relation

$$\frac{\pi}{16} D^3 f_0 \text{ or } \frac{\pi}{16}\frac{D^4 - d^4}{D} f_0 = K\sqrt{B^2 + T^2} \quad . \quad (12)$$

where K is a coefficient having the value

$$K = \frac{8}{\sqrt{1 + \left(\frac{B}{T}\right)^2}} \times \frac{\left(\cos 2\phi + \frac{B}{T}\sin 2\phi\right)^3}{(8 - 5\delta + \delta^2)\cos^2 2\phi + (6-\delta)\frac{B}{T}\sin 2\phi\cos 2\phi + 2\left(\frac{B}{T}\right)^2 \sin^2 2\phi} \quad (13)$$

Equations (10), (12) and (13) may be employed to determine f_0 in any given case where B T, δ D and d are known. A more important application, however, is in connection with the problem of design. It will be seen that if it is required to design all shafts to have the same factor of safety with reference to their ultimate breakdown or limiting fatigue strength under straining actions similar in kind to those which they have to sustain in practice, then f_0 will be a constant, and will equal the permissible static shear stress for the material, *i.e.*, the stress allowable when the straining action is a constant twisting moment. Equation (12), therefore, may be regarded as the Guest formula modified by a coefficient K, which enables it to be applied over the whole range of combination of B and T without alteration of the stress f_0. It is necessary to observe, however, that f_0 is not the maximum shear stress, and, in general, will not refer to the plane upon which the maximum shear stress acts, but is the static equivalent of the most destructive shear stress, the plane of which is given by the angle ϕ. In order that equation (12) may be used without much labour the value of K needs to be known. Values of ϕ and K have been calculated from (10) and (13) for different values of $\frac{B}{T}$ when δ has the values 0, 0.5, 1.0, 1.5 and 2; these are given in Table II, and in Fig. 2 the value of K is shown plotted against the ratio $\frac{B}{B+T}$.

The results obtained require comment. Referring to Fig. 2, case $\delta = 0$, the curve S Q gives the value of K obtained from (10) and (13); and the curve M R N P gives the value of k obtained from (13) when

$$\phi = 45° \quad \left(\text{in this case } K = \frac{4\,B}{\sqrt{B^2 + T^2}}\right).$$

The former refers to the most destructive shear stress due to the combined action of B and T, while the latter refers to the most destructive shear stress due to B only. The latter, of course, occurs on a plane making 45 deg. with the plane of torsion, and on this plane T contributes a normal stress only; and hence, according to the assumptions made in regard to the breakdown of a ductile material, it does not influence failure on this plane. Intersection of the curves S Q and M N P in the manner shown by the figure indicates that when the ratio $\frac{B}{B+T}$ is greater than 0.25, approximately, the bending moment by itself is responsible for breakdown. Or, put in another way, a shaft designed to resist a reversing bending moment only may support in addition a constant twisting moment having a magnitude up to three times the maximum value of the bending moment without altering the value of the most destructive shear stress set up. Unless, therefore, the twisting moment is more than three times the bending moment, according to this investigation it is sufficient in the case considered to design a shaft to resist the bending moment only. Also it will be observed that even when $\delta = 0.5$ the twisting moment, for most practical purposes, may be left out of account when it is less than twice the bending moment. These are most important deductions, which need experimental investigation if the grounds

TABLE II.—(N.B.–THE SLIDE-RULE HAS BEEN USED FOR ALL CALCULATIONS.)

CASE.		$\frac{B}{T}$	0	0.1	0.25	0.5	0.75	1.0	2.0	4.0	∞
		$\frac{B}{B+T}$	0	0.0909	0.2	0.333	0.428	0.5	0.667	0.8	1.0
$\delta = 0$	{	ϕ	0	6° 45′	16° 44′	45°	45°	45°	45°	45°	45°
	{	k	1.0	1.02	1.134	1.79	2.4	2.83	3.58	3.88	4.0
$\delta = 0.5$	{	ϕ	0	5° 51′	14° 44′	29° 33′	28° 43′	40° 19′	Practically the same		45°
	{	k	1.39	1.412	1.534	1.939	2.47	2.884	as case $\delta = 0$		4.0
$\delta = 1.0$	{	ϕ	0	5°	12° 32′	24° 15′	31° 35′	34° 50′	39° 1′	41° 34′	45°
	{	k	2.0	2.026	2.144	2.43	2.73	3.11	3.66	3.9	4.0
$\delta = 1.5$	{	ϕ	0	3° 54′	9° 27′	16° 40′	23° 5′	27° 5′	34° 55′	39° 46′	45°
	{	k	2.908	2.93	2.99	3.16	3.36	3.51	3.8	3.96	4.0
$\delta = 2$	{	ϕ^*	0	2° 52′	7° 1′	13° 16′	18° 26′	22° 30′	31° 44′	37° 59′	45°
	{	k	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0

* ϕ in this case is the inclination of the plane on which the maximum shear stress acts.

upon which they have been made appear at all reasonable.

Fig. 3 has been drawn to exhibit more clearly the distribution of the shear stresses in the material at the surface of a shaft for the case $\delta = 0$ when the most destructive shear stress is due to the bending moment only. It refers to the case where $B = \frac{3}{8}T$, or $\frac{B}{B+T} = 0.273$. Comparing Figs. 1 and 3, the origin of co-ordinates 0 in Fig. 3 corresponds with the point A in Fig. 1; O X corresponds with A B; and the angle co-ordinate θ corresponds with the inclination of A C to A B; while the radial co-ordinate represents the shear stress on the plane A C. In plotting the diagram the maximum shear stress in the plane of torsion is regarded as unity. The dotted curve C D C′ shows the maximum value of the shear stress on any plane, and is symmetrical about O A, 45 deg. with O X. The two branches of the curve, however, do not represent stresses which occur simultaneously. The stresses represented by C′D occur when the shaft has turned through 180 deg. from the position occupied when those represented by C D are in existence. The full line curve B A B′ is plotted from equation (9) and represents the values of the static stresses equivalent in destructiveness to the actual dynamic stresses. It reaches a maximum value at B, for which the angle θ given by equation (10) is 28 deg. 21 min., and a larger maximum value at A, due solely to the bending moment. This curve is also symmetrical about O A. The maximum stress O B is represented by the point Q in Fig. 2; while the stress O A is represented by a point on M N P vertically above Q.

Little comment is called for in the cases where δ has other values than zero. It will be found that the stress curves shown as in Fig. 3 do not possess symmetrical branches, but have their maximum values at the angles ϕ given by equation (10) and Table II. When $\delta = 2$ both the bending and twisting moments reverse in synchronism, and the most destructive shear stress is then the maximum shear stress.

The use of the curves given by Fig. 2 is apparent. The ordinary procedure in problems of design when B and T are known is to estimate the ratio $\frac{B}{B+T}$, read off from the curves the value of K corresponding to the range of variation of T, and by means of equation (12) determine the shaft size in the usual manner. In selecting a value for f_0, however, it will be advisable in all cases, except where the straining action is practically all torsion having little variation, to take f_0 as four times (this is the value of the ratio of the resistances of the material to static and reversing shear stresses assumed by equation (3) employed in the foregoing investigation) the working shear stress p applicable to the case of complete reversal of stress. The stress p, of course, is one-half the working direct stress for complete reversal of load, and hence f_0, determined in the way suggested, will be twice this stress. For example, in the case of mild steel a working direct stress of 5,000 lb. per sq. in. is commonly taken for the case of complete reversal; the corresponding value of f_0 is 10,000 lb. per sq. in. By selecting f_0 in this way it will agree most closely with results of experiment for cases where the stress varies considerably; and for all practical purposes the results will be the same whichever of the equations (2) or (3) is made the basis of investigation. In cases where the straining action approximates to a constant twisting moment, f_0 may be made equal to the static working shear stress for the material. By proceeding in this manner the results obtained by this investigation may be regarded as of general application to all steels as used for shafts. Some engineers, when designing parts subjected to varying stresses, instead of using a common factor of safety (real) for all cases, prefer a factor of safety against fatigue, and a limit to the maximum stress as a safeguard against deformation of the part. In the present instance the maximum shear stress will not be greater than any value f_m if the coefficient K has a value not less than $\frac{f_0}{f_m}$. It is obvious that other sets of curves similar to those of Fig. 2, but applying to such cases as, for example, a constant twisting moment combined with a bending moment varying by different amounts, may be worked out on the same plan.

In conclusion it must be borne in mind that the curves given by Fig. 2 are the result of certain assumptions which may, or may not, be quite justified; and, until there is further evidence, upon which a more exact inquiry may be made, they are offered only as a guide. That there must be such a set of curves is obvious; their correct shape for different materials, however, can only be given either when the breakdown of materials under compound stresses of a varying character is fully understood, or when sufficient experimental evidence on the strength of test-pieces under combined bending and torsion of this kind has been accumulated, from which such curves may be plotted. A considerable need exists for information upon the behaviour of materials subjected to bending and torsion under conditions commonly met with in practice. If the foregoing speculation has any approximation to facts it would seem to justify an experimental inquiry into the question of how far a constant or slightly varying twisting moment may be added to a reversing bending moment, when applied to a shaft, without increasing the destructiveness of the straining action. Quite apart, however, from any theoretical investigation of the foregoing character, if a ductile material subjected to either a reversing twisting moment or bending moment fails by shear on the plane of maximum shear stress, and at the same comparatively small value of shear stress in the two cases, it is quite reasonable to expect that, up to a certain point, a constant twisting moment may be added to a reversing bending moment without appreciably altering the plane of fracture or influencing breakdown. The writer would like to suggest that an investigation into this matter would form a subject for useful experimental research.

SELENIUM CELL AS BURGLAR ALARM.—Under the trade name "the electric eye" Dr. O. Hannach, of Berlin, is introducing a sensitive selenium cell, which will give a signal when it is illuminated by the flame of a match at a distance of 10 m. The selenium cell acts in the usual way as a relay. The cell is small (*Elektrotechnische Zeitschrift*, May 3, 1917) and can easily be hidden in the decorations of a safe or piece of furniture and covered with glass. The advantage claimed over ordinary burglar alarms is that the device will operate as soon as a light is introduced into the dark room, whilst other alarms have to be excited by the breaking an electric circuit or by mechanical vibrations. As the electric eye works with a suspended coil, however, accidental vibrations might make it more sensitive than is desired.

THE HARLEM RIVER SUBWAY TUNNEL, NEW YORK.

By FRANK W. SKINNER, M.Am.Soc.C.E.

(*Concluded from page* 33.)

Launching and Floating the Tubes.—In order to exclude the water and give buoyancy for floating all the ends of the tubes were closed by temporary wooden bulkheads bearing against riveted inside angle flanges. Semi-bulkheads were also built at the quarter points, making airtight diaphragms across the upper part of the tubes and dividing them into three chambers each, to form air traps and prevent plunging when the tubes were sunk. The positions of the bulkheads in tubes and their general character are shown by Figs. 24 to 37, on page 84, while the end bulkheads will be also seen in Fig. 39 on Plate X. The view last referred to, together with Fig. 38 on the same plate, show two stages in the preparation of the tubes for sinking.

The bulkheads at the shore ends of the end sections of tubes were of heavy construction, to resist the pressure of nearly 60 ft. head when fully submerged and the tubes pumped out. The other end bulkheads of the outside tubes were only required to resist a pressure head of about 5 ft., and were made much lighter, those for the inner tubes being only 5 ft. high. All the full-height bulkheads were provided with long-stem, 10-in. and 12-in. inlet valves for scuttling the tubes, and each outer tube had in the upper part one 2-in. air vent at each end and one 3-in. air vent right back of each semi-bulkhead. (See Figs. 25, 26, 29, and 31, on page 84.)

The bulkhead joints were caulked with oakum. Full-height and full-length longitudinal bulkhead walls of 4-in. horizontal planks were bolted to the vertical flange angles of the diaphragms connecting the tubes, and intermediate between the diaphragms the timber walls were braced by radial angles riveted to the outer tubes, as shown in our illustrations.

Under each tube section on the falsework nine 14-ft. by 80-ft. wooden scows, each loaded with enough rock to nearly eliminate its submerged buoyancy, were placed at low tide. Their freeboard was sufficient to give each a buoyancy of about 100 tons, which, with the 8 ft. rise of tide, lifted the 800-ton section and moved it clear of the falsework.

The scows were then scuttled and a tug pulled them free of the tube section, which floated with about 3 ft. draught, as seen in Fig. 39, Plate X. The tubes were towed to a convenient mooring and their fittings completed, while another tube section was built on the falsework in the slip.

Pneumatic Control Cylinders.—To balance the submerged weight, control the tubes under water, and enable them to be easily and conveniently handled and sustained at any required position free of bottom support, each tube section was provided, while floating, with four horizontal transverse air cylinders, 10 ft. in diameter and about 68 ft. long, two of which were secured across the tops of the tubes at each end, as shown in Fig. 24, page 84. These air cylinders, which can be seen in position in Fig. 39, Plate X, and Fig. 64, Plate XIII, provided very delicate, efficient and rapid control of the sinking suspension of the tubes, and were the most novel and important feature of the tunnel-sinking process, without which or its equivalent it would have been impossible to execute the work safely and satisfactorily.

Each cylinder was made of $\frac{5}{16}$-in. plates and had domed ends and two domed transverse diaphragms calculated to resist heavy unbalanced pressures. Each was thus divided into three independent airtight chambers, proportioned carefully to have sufficient buoyancy to lift the submerged weight of the tube sections, and so that the centre chamber should develop sufficient buoyancy to float the cylinder when the end chambers were filled with water. The buoyancy of each group of four cylinders amounted to 722 tons, while the weight of a section of tubes when submerged was about 646 tons, the excess buoyancy of the controlling air cylinders being thus about 76 tons. The cylinders were tested by pressures of 30 lb. per square inch in the end and 50 lb. in the centre chambers. The construction details of the cylinders are shown clearly in Figs. 40 to 47, on Plate XI.

The cylinders were each seated at two points on

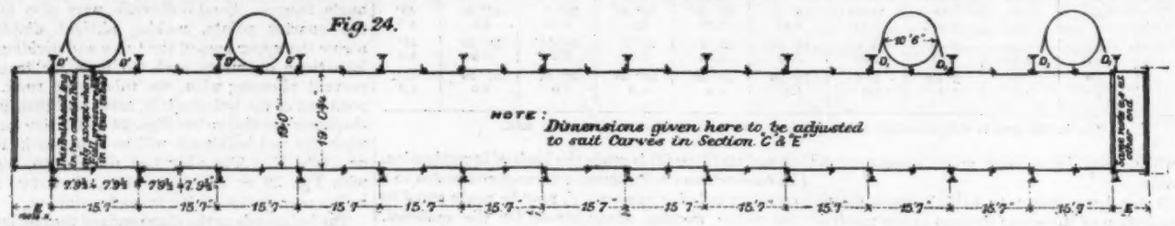
wooden cradles and were tightly secured to the tube diaphragms at these points by pin-connected sleeve-nut ties passing over saddles on the tops of the cylinders, as shown in Fig. 45, Plate XI, details of the connections being given in Figs. 48 and 49. In the planes of these saddles the cylinders were reinforced against the heavy shears by semi-diaphragms and radial braces, as also shown in Fig. 45, while between these points and the ends they were braced by sets of eight radial struts, as seen in Figs. 43 and 47. Each end chamber of a control cylinder was provided at the top with a 4-in. globe valve connected to a 4-in. pipe extending through and nearly to the bottom of the cylinder, and by means of which the compartment could be filled or emptied as required. The centre chamber of each cylinder was provided with a 3-in. inlet valve in the bottom, commanded by a long valve stem passing through the top of the cylinder, as shown in our illustrations. By this valve water could be admitted to adjust the buoyancy of the cylinder. Each centre compartment was also provided at the top with a 3-in. globe valve attached to a 3-in. pipe extending to within 1½ in. of the bottom of the cylinder, while there was also provided a 2-in. valve having a connection to which could be attached a hose extending to the surface of the water and through which air could be forced in order to expel water from the cylinder.

Two temporary vertical steel masts 43 ft. high were attached to the ends of the tube sections to facilitate their alignment after submersion; each was braced by an adjustable stiff-leg and two adjustable guy rods to provide for plumbing in any direction. The masts carried horizontal cross-arms with targets, the centre of each target being 1 ft. outside the centre line of the outer steel tube. The targets could thus be simultaneously aligned by an offset transit. Each mast had also clamped to it at its upper end a thin metal plate divided into feet and tenths, and thus serving the purpose of a level rod. The constructive details of these masts and their connections are shown by Figs. 50 to 53, on Plate XII, while the masts will also be seen in position in Fig. 39, on Plate X, and Fig. 64, Plate XIII, these two last-named views showing a section of the tubes floated ready for sinking.

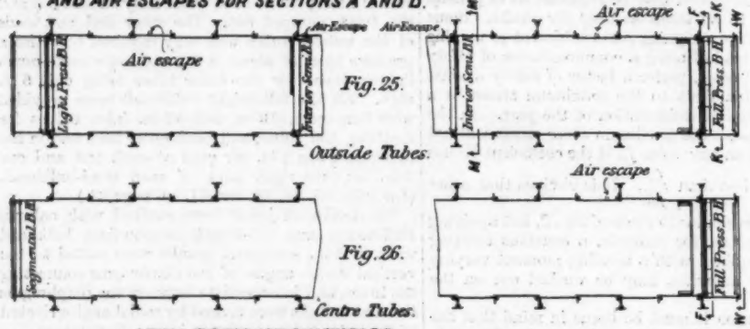
Sinking the Tube Sections.—On August 29, 1913, the first tube section was towed about 1 mile from its mooring, through three drawbridges and against a three-mile tidal current, to its site, in 1½ hours, by two tugs in front and one tug behind. It was adjustably moored in position by a transverse tackle attached to each side on the ends, four in all, and each anchored to a separate cluster of piles and operated by a hoisting engine on a pile-driver barge moored between the anchor piles. A fifth longitudinal tackle was attached to one end of the section, and a bridle was shackled to the diaphragm at each end of the section and connected to the boom of an 80-ft. 10-ton-capacity derrick. This derrick was mounted on a scow moored on one side of the section to be sunk, while the concrete mixing scow (to be dealt with later) was on the other side.

All being ready for sinking, the bulkheads were next partly removed from the ends of the centre tubes, and in 42 minutes after the 12-in. valves in the end bulkheads of the outer tubes were opened the tubes were completely submerged and the air control cylinders touched the surface of the water. About 25 minutes later the escape of the air from the upper parts of the tubes was completed, and they were supported wholly by the buoyancy of the control cylinders, each of which exerted excess buoyancy of about 19 tons. Hose pipes about 15 ft. long had been connected to the 2-in. air escape pipes in the tops of the tubes, so that the air could be controlled by men on top of the cylinders, but this was found to be necessary

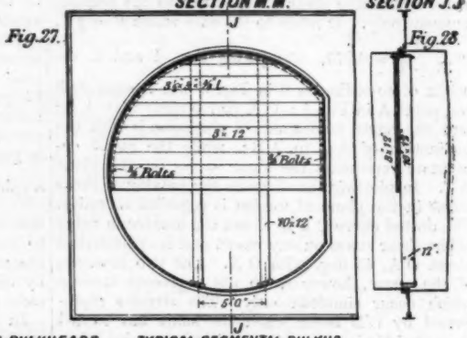
Fig. 24.

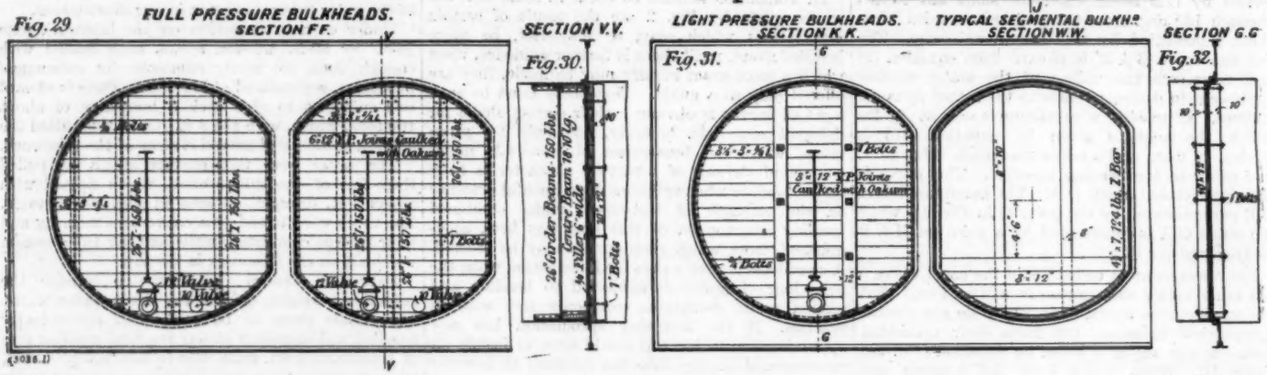


LONGITUDINAL SECTION THROUGH TUBES SHOWING LOCATION OF BULKHEADS AND AIR ESCAPES FOR SECTIONS A AND D.



AIR CURTAIN INTERIOR SEMI BULKHEAD. SECTION M.M. SECTION J.J





DETAIL OF CONNECTION FOR 20" I BEAM.

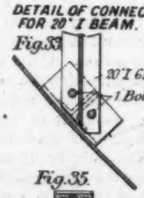


Fig. 34. DETAIL OF CONNECTION FOR 26" I BEAM.

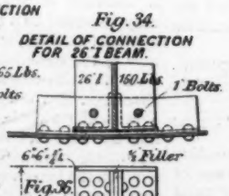
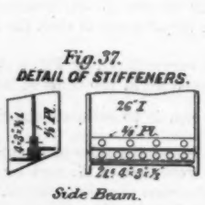
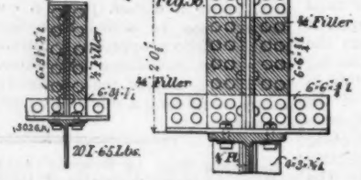
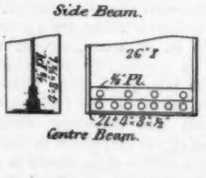


Fig. 37. DETAIL OF STIFFENERS.







in only one or two instances, as the tubes sank very steadily on an even keel.

The inlet valves in the centre chambers of all the control cylinders were next opened, and in 40 minutes the latter were completely submerged, the whole mass being sustained by the derricks, these exerting a lifting force estimated at rather less than 5 tons each and maintaining the tubes about 20 ft. above their final positions. The total weight of the submerged structure was then about 646 tons, or 7,440 tons including the contained water, an enormous mass to be handled by two derricks. Fig. 64, on Plate XIII, shows one of the sections in position ready for sinking, its ends being connected to the two controlling derricks mounted on the adjoining scow.

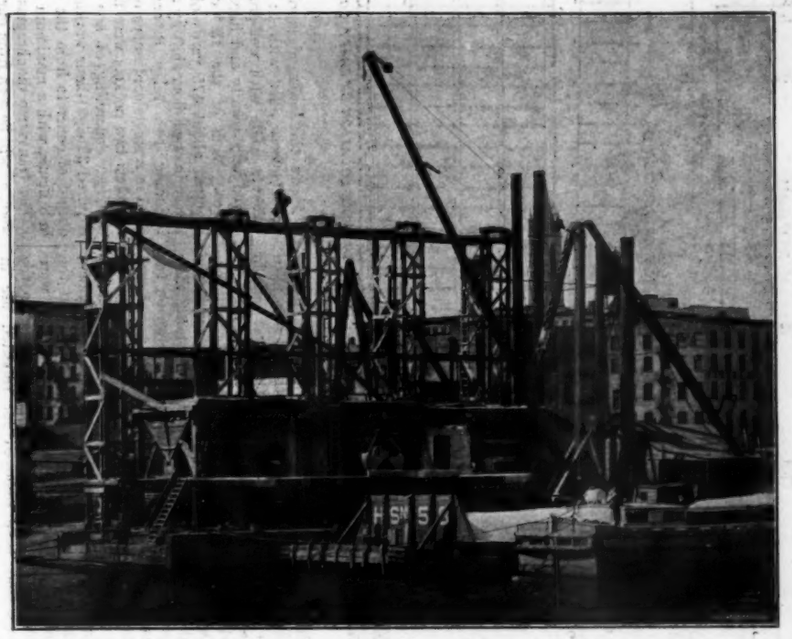


FIG. 66. FRONT VIEW OF SET OF CONCRETING TOWERS, WITH FLOAT CARRYING CONCRETE-MIXING PLANT.

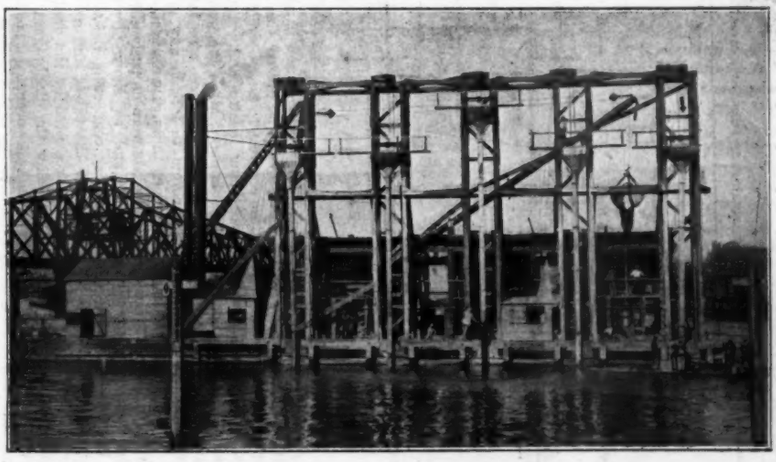


FIG. 67. BACK VIEW OF SET OF CONCRETING TOWERS.

About three hours after the inlet valves in the tube were opened the derrick tackles were slacked and the tubes lowered to alignment, bearing on five horizontal longitudinal sills at each end, previously set by divers to the exact level of the bottom flanges of the transverse diaphragms and intended only to fix the vertical adjustment of the tubes without supporting any essential portion of their weight. Each sill consisted of a pair of vertical-web 12-in. channels bolted through gusset plates to the shouldered tops of a pair of wooden timbers, 12 in. square, pointed at the ends and 10 ft. long, together forming knee-braced bents, driven with a pair of long steel followers by a pair of floating steam-hammer pile-drivers. This and the succeeding tube sections required to be shimmed up a little on the sills by divers to bring them to within ¼ in. of exact vertical position. The first tube section took bearing with longitudinal and transverse displacements of 2.2 ft. and 4 ft. respectively, due to the three-mile tidal current, and was adjusted to exact position and alignment by the mooring tackles and checked by transit observations on the targets, already mentioned as being carried by the masts described.

The succeeding sections were sunk in the same manner and in about the same time, and each was connected to the preceding section by a pair of horizontal longitudinal pilot pins, 5 in. in diameter and 3 ft. 6 in. long, each fixed at one end in the casting at the foot of an alignment mast and pointed at the projecting end. This pointed end was entered into the coned hole in a casting attached to the previously sunk tube section by pulling the last section endwise into contact with the preceding one, thus automatically centring it. The play between each pin and the contracted end of the conical socket was only ⅛ in., and as soon as the pin was "home" a tapered key was driven through a slot in the pin near its pointed end, this key taking a bearing against the socket casting and preventing the pin from slipping out. One of these coupling pins, together with its connections, is shown in full detail in Figs. 59 to 63, on Plate XII. The adjoining sections, having been brought into line in the way above explained, were next bolted together by ⅞-in. bolts passing through the exterior 3½-in. by 3½-in. by ½-in. angle irons mentioned in the earlier part of this article as surrounding the ends of the tubes. The bolts, which were placed at about 18 in. pitch, were inserted by divers. The angle irons here referred to will be seen in Fig. 59, Plate XII, while the whole joint is shown to a larger scale in Fig. 88, on page 94. From the section there given it will be seen that the external angle-iron rings are supplemented by internal rings of Z-irons. After the tubes had been unwatered the outstanding flanges of the adjacent Z-iron rings were connected by a plate, 13½ in. wide and ⅜ in. thick, as shown in Fig. 88, the pocket formed between this plate and the shell of the tubes being filled with grout. The operation of bolting-up the sections by the divers, above described, occupied about a day, and while it was being carried out the end of the new section adjoining that already placed was supported on the pilot pins while the outer end rested lightly with its last diaphragm on the sills already mentioned, and was duly adjusted for level and alignment.

Exterior Concreting. — The exterior concrete, amounting in all to about 40,000 yards, was all mixed in a floating plant and deposited in place by the tremie method. The plant was installed in a 35-ft. by 110-ft. section of a wooden car float, and included two 45-h.p. steam boilers, an air compressor, three concrete mixers, concrete hoisting apparatus, five fixed timber towers and tremie tubes, three hopper-bottom 8-yard double storage bins for sand and gravel, and, below the deck, tanks with fresh city water for concrete mixing and boiler use. Figs. 66 and 67, on the present page, show respectively front and back views of a set of the concreting towers, the first-named view also showing the concrete-mixing plant carried by the float. The installation will also be seen in Fig. 65, on Plate XIII.

The 6-ft. by 6-ft. braced wooden towers, 50 ft. high, were located along one side of the scow, overhanging the edge, being spaced to correspond to the distances between the tubes and between the outside tubes and the longitudinal bulkhead walls. Sand and fine gravel were discharged by gravity from the storage bins to the mixing machines, and the concrete was deliverable from the latter to 1-yard steel buckets hoisted by separate engines to the tops of the towers between vertical guides.

The buckets discharged into 1¼-yard hoppers on the tops of vertically movable 12-in. steel tremie tubes, 60 ft. long. A railed working platform for the operator was attached to the tremie hopper and was suspended from a rope passing over a sheave in the top of the tower for raising and lowering the tremie through a range of about 40 ft. This operator commanded this movement by an endless rope passing over the top of the tower and attached to the throttle lever of the engine operating the hoisting tackle.

Sand and gravel were delivered on 500-yard deck scows and unloaded to the storage bins by a 1½-yard clamshell bucket operated by the 80-ft. boom of a stiff-leg derrick on the deck of the concrete float. This derrick will be seen in the view Fig. 66 on the present page.

The concrete scow, moored at both ends by tackles to anchor piles, was placed above the submerged tubes with its axis transverse to them, and was adjusted so that the tremies were lowered to the bottom, one in each space between tubes and one in each outside space between tubes and bulkhead, in the same 15-ft. by 76 ft. pocket between transverse diaphragms.

One or two dry batches of concrete were first

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Fig.68. SECTION V.V.

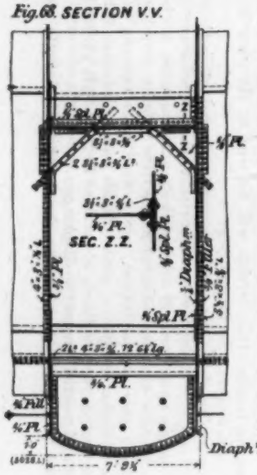


Fig.69. CROSS SECTION THROUGH SUMPS, LOOKING SOUTH.

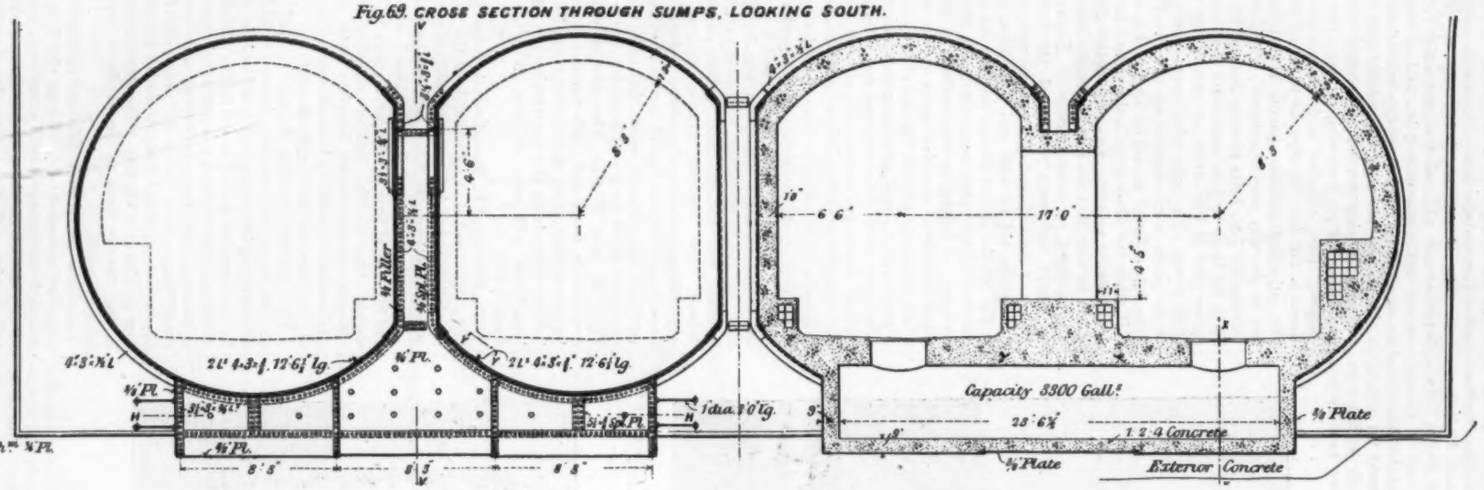


Fig.70. VIEW Y.Y. Showing Rivet.g of 2 4·3·¾ Tie Ang.s

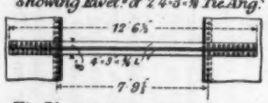


Fig.71. SECTION X.X. Showing Concrete Lining

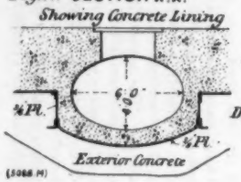


Fig.72. HORIZONTAL SECTION H.H.

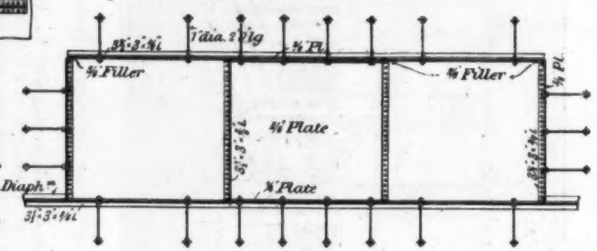


Fig.73. ACCESS SHAFTS CROSS SECTION

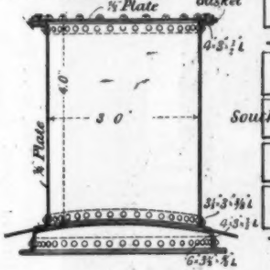
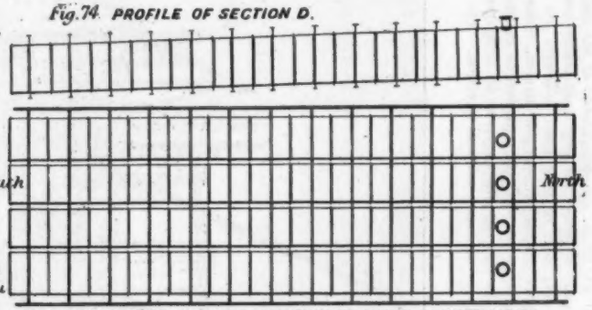


Fig.74. PROFILE OF SECTION D.



PLAN OF SECTION D SHOWING LOCATION OF SHAFT CONNECTIONS.

dumped into each tremie hopper, forcing the water out of the pipes, which were then filled with wet concrete, which was frequently added to keep them filled approximately to the top as it escaped from the bottom. Lifting the pipe a few inches allowed the concrete to flow out at the bottom, spreading over the bottom of the trench inside the pocket at a very flat slope.

The bottoms of the trenches were kept 3 ft. or 4 ft. below the surface of the deposited concrete, insuring a good seal for the tremie tubes. In this way all danger of washing was avoided, and the concrete was exposed to the action of the river water only on the upper surface of the deposited mass in the enclosed pockets, where there was no current. A high grade of uniform dense concrete was thus secured.

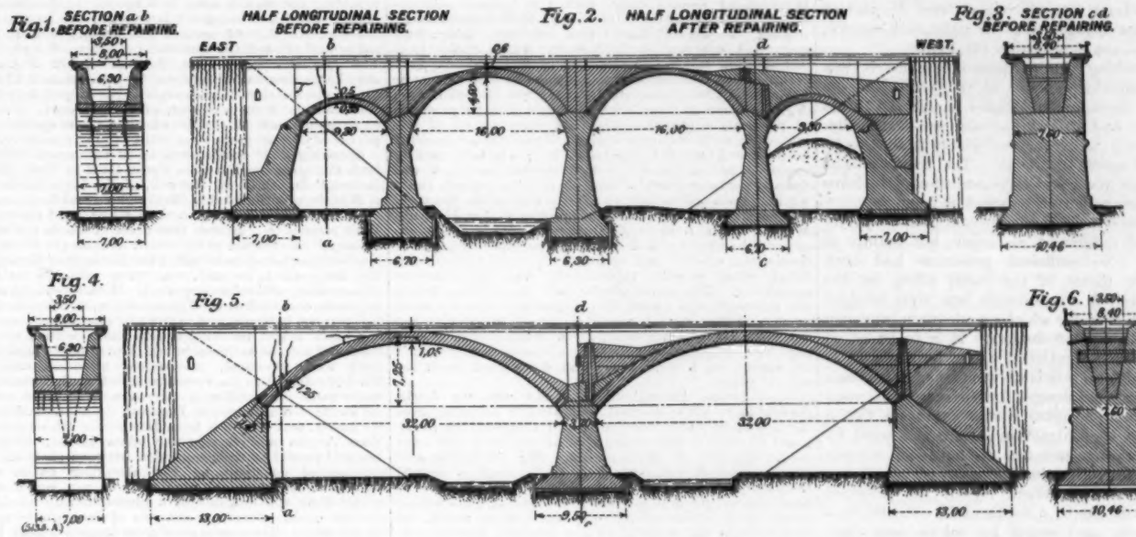
The tremies were carefully watched and handled rapidly by expert operators, who raised the full tremies and allowed the concrete to escape while the concrete buckets were being hoisted and emptied automatically into their hoppers, all of the tremies being operated simultaneously. Care was taken never to allow the concrete to remain any great length of time in the tremie tubes. Divers were employed to see that the pockets were properly filled.

As already explained, and as shown by our illustrations, the diaphragms connecting the tubes extended 2 ft. 3 in. below the tubes, and as the bottom of the trench as excavated by the dredger was from 1 ft. to 2 ft. below the diaphragms, the bottoms of the shells of the tubes occupied a position from 3 ft. 6 in. to 4 ft. above the trench bottom, and this space was filled with concrete. Up to subgrade, which was the level of the lower flanges of the transverse diagrams, the trench was filled with 1:4:8 concrete. When this was all in place and provided bearing for the steel tubes to distribute their weight over the bottom of the trench, the water was admitted to the air chambers in the middles of the control cylinders, overcoming their buoyancy and causing them to settle down on the tubes, and the weight of the latter to be transferred to the concrete in the pockets. The derrick tackles were then slacked off. Divers next descended and disconnected the attachments of the control cylinders to the tubes, and air was then pumped into the centre compartment of the former until they were floated by their increasing buoyancy, rose to the surface, and were removed for repeated use in sinking succeeding sections of the tubes.

Above the lower edges of the diaphragms the pockets were filled with 1:3:5 Portland cement concrete made with well-graded 1-in. gravel that flowed very readily and filled all space around the tubes. Each of the 13 pockets in one section required about 475 yards of concrete, which was placed in one 8-hour shift by a total force of 35 men, including two relay divers. Each pocket was filled in a single continuous operation, and on some occasions two pockets were filled in one day. The complete concreting of one tube section usually required 32 eight-hour working days. The average output of concrete from the mixers was 360 yards in 8 hours, with a maximum of 700 yards.

The transverse diaphragms connecting the tubes were, as will be seen from our engravings, so spaced that the joint between two adjacent sections came

FAILURE OF REINFORCED CONCRETE BRIDGES IN PRUSSIA.



in the middle of a pocket. In this joint pocket a richer concrete, 1 : 2 : 4, was used, the object being to secure the tightness of the joint until the covering plate connecting the flanges of the Z-iron rings could be put in place as already described.

When a number of the pockets—say, three or four—sufficient to give a section a support on the bottom had been filled, the air cylinders were detached for use in the sinking of the next section. In order to do this, water was admitted to the cylinders by the valves provided for that purpose, thus causing them to settle down on the tubes and leaving the connecting hangers loose. The hangers were then disconnected and removed by divers and, compressed air being admitted to the centre compartment of each cylinder, the water was driven out and the cylinders rose to the surface. The end compartments were then emptied and the cylinders were ready for re-use.

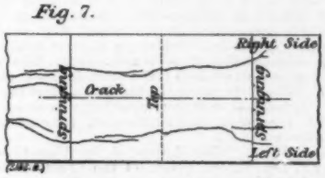
Unwatering the Tubes.—After all the tube sections were sunk, connected by divers, and concreted outside, their interiors were accessible through four 3-ft. vertical shafts near one shore, bolted by divers to the connections previously mentioned, which had been temporarily closed by cover plates. In these shafts were placed two 4-in. pulsometers, one 6-in. centrifugal, and one 9-in. plunger pump, which were lowered as the water-level fell, and; pumping against a maximum head of about 50 ft., removed the 6,700,000 gallons of water in about 13 days.

The pumps removed a large part of the silt that filled the invert of the tubes to a depth of from 6 in. to 24 in., and the remainder was wheeled to the shafts and hoisted out. The joints between the tube sections were spliced by the circular inside cover plates bolted on the internal flanges of the Z-bars previously described, small leaks through bolt holes were stopped by tightening up the nuts, and the tubes were found tight and dry and in good condition, and all work in them was done without any difficulty under atmospheric pressure.

Lining the Tubes.—As soon as the tubes had been cleared of water they were lined internally with concrete mixed in the proportions 1 : 2 : 4, this concrete being reinforced by steel rods, 1 in. square, spaced at 12-in. centres, besides being connected by the yokes and bolts already mentioned. The concrete lining is 12 in. thick on the vertical walls, 2 ft. 10 in. thick at the inverts and 15 in. elsewhere. The invert was first put in place and the sides and top of the lining were then placed in one operation, the work being done in 30-ft. lengths. Timber forms, partly collapsible, were used, these forms being 30 ft. in length and being moved as wanted by the aid of a traveller.

As mentioned in the early part of this article, the subway was provided with drainage sumps at

Fig. 7.



about the middle of its length, and sections through the work at this point are given in Figs. 68 to 72, on page 86. On the same page Fig. 73 shows one of the shaft connections, and Fig. 74 the location of these connections on section D of the subway tubes. In Fig. 69 the two left-hand tubes are shown without the concrete lining, while in the case of the two right-hand tubes the form of this lining is shown in the case of both tubes and sump.

Figs. 75 to 79, on page 94, give particulars of both the external and internal concreting, and are really self-explanatory, while Figs. 80 to 93, on the same page, show further constructive details of the tubes which supplement those on Plate V, published in our issue of the 13th inst. Amongst these we may mention specially the details of a cross-opening, connecting adjacent tubes, shown in Figs. 89 to 93. A section through one of these openings is also given in Fig. 78.

While the lining of the subway was in progress the land connection at the north end was constructed, this work being carried out by the aid of a cofferdam about 60 ft. deep, built of steel piling and suitably connected to the first section of tubes by attachments provided for that purpose. An earthen embankment was formed against the exterior of the cofferdam to give it stability, and it was, of course, very strongly braced internally. It proved very successful, and a similar arrangement was adopted in the construction of the approach at the southern end of the subway.

The construction of the Harlem River Four-Track Subway was carried out under the direction of the engineers of the Public Service Commission, New York City, Mr. Alfred Craven being the chief engineer and Mr. Robert Ridgeway engineer of construction. The contractors for the work were the Arthur McMullen and Hoff Company, Mr. N. R. Melvin being the superintendent and Mr. G. A. Graham and Mr. G. Muller the assistant engineers, while the consulting engineer was Mr. Olaf Hoff, whose previous use of the system of construction adopted has already been mentioned.

NORWEGIAN SHIPPING.—A large new steamship company is in course of formation in Norway under the style of the North Sea and Baltic Line; the minimum capital is 10,000,000 kroner, maximum 13,000,000 kroner.

FAILURE OF REINFORCED CONCRETE BRIDGES IN PRUSSIA.

IN a recent issue of *Le Génie Civil* we find an interesting description of the partial failure in Prussia of some reinforced concrete viaducts, built in 1910–11, to carry a double line of railway. One of these structures carries the railway over a stream and an adjoining roadway, whilst the other crosses a canal. The general character of the former of these structures as originally built is represented by Fig. 1 and by the left-hand half of Fig. 2, whilst corresponding views of the canal bridge are represented by Figs. 4 and the left-hand side of Fig. 5. In the case of the canal bridge there was trouble during erection owing to the collapse of the eastern abutment. This failed because of the use of forms and shuttering which proved too weak to hold up the concrete whilst setting and hardening, a process which had been retarded by frost. The cement used, moreover, turned out to be of indifferent quality and to have been in lower proportion than required by the specifications. These provided for a ratio between cement and aggregate of 1 to 10, but the actual figures turned out to be in the ratio of 1 to 11.6. As a consequence the work had to be rebuilt under more rigid inspection and with a more liberal supply of cement. Both bridges were brought into use in July, 1912. At the end of March, 1913, an examination made before definitely taking over the works led to the discovery of a number of cracks in the bridge represented by Fig. 2. In the case of the western abutment these cracks extended over the whole of the intrados, as indicated in the plan view, Fig. 7, and also in the cross-section, Fig. 1. The principal cracks were situated just outside of the base of the spandril walls, and were open to the extent of 7 mm. at the crown and 3 mm. at the springing line. It was found that they extended throughout the whole depth of the arch-ring; there was, moreover, a capillary crack along the centre line of the arch. The other abutment of this bridge also showed cracks, but less seriously developed, whilst the main arches appeared sound. In the case of the canal bridge cracks were found both in the axial and the transverse directions, as represented in Figs. 4 and 5.

Matters got worse as time went on, and in 1914 it was considered necessary to reduce the speed of all traffic over the bridges. In the case of the bridge represented in Figs. 1 and 2 the attempt was made to check further development of the cracks by tie-rods 50 mm. in diameter passing transversely through the structure from one side to the other. These took their bearing on a grillage built up of flat bars and channels sunk into the outer

faces of the arches. This finally checked the spreading of the cracks, but was considered to be a temporary expedient only. To make permanent repairs it was, however, necessary to divert the traffic over an old single-track line which had been dismantled when the new bridges were brought into service, and this was not practicable till 1915.

On undertaking the permanent repairs it was found that certain tie walls of reinforced concrete intended by the sanguine designer to take the thrust of the filling and ballast had also cracked badly. These tie walls were far too widely spaced to be effective and much too weak. The reinforcement was of 10-mm. rods, and these were found to have slipped at their ends to the extent of 2 cm.

The troubles described obviously originated partly in the use of indifferent materials, but mainly in bad design. No sufficient provision had been made for the thrust of the earth filling on the spandril walls. A cross-tension was thus brought on to the arch ring, for which no adequate provision had been made in the designs. It is to be noted that the tie walls mentioned above were put in as an afterthought, no provision whatever having been made in the original designs for the cross-tension on the arch ring. The cross cracks shown in Fig. 5 are attributed to contraction strains produced by changes of temperature and to tensional stresses produced by the rolling load.

In making the permanent repairs the principal cracks were cut out to a depth of 10 cm. and to a width of 6 cm. and sealed by oakum and clay. Water under pressure was then forced into the crack in order to thoroughly wet the material, and this was followed by a grout of cement mortar injected under a pressure of 3 atmospheres. A second application of the grout was made eight days later. A part of the arch was, moreover, demolished and rebuilt, during which operation it was necessary to carry the remainder on heavy centering. Finally the 'tween space between the side walls was piled up with a light cement, as indicated on the right in Figs. 2 and 5, and by the cross-sections, Figs. 3 and 6. These works of reconstruction cost as much as did the original construction of the bridges.

THE SOCIETY OF CHEMICAL INDUSTRY.

A LARGE number of papers of varied character were brought before the annual meeting of the Society of Chemical Industry, which was held last week, on July 18 to 20, at Birmingham. Several of the subjects discussed have repeatedly been noticed in our columns. This applies in particular to the discussion on "Refractory Materials" by the Faraday Society, which we noticed in our issues of November 10 and 17, 1916, on pages 464 and 489 of vol. cii. The full report of this discussion has just been published in the Transactions of the Faraday Society. We abstract some of the papers read at Birmingham, of more direct interest to our readers, in the following lines, beginning with communications of a general character.

Mr. Herbert W. Rowell presented two papers, the first on "Some Principles of Industrial Research Organisation." Industrial research, Mr. Rowell said, should be State-aided and systematically encouraged by the manufacturers. With regard to the personality of a leader for this organisation, he pointed out that the only fit person to undertake the control of research and the development of industrial technique was the scientifically-trained chemist, engineer, or physicist, as the nature of the work demanded. The initiation, organisation and carrying through of all research and experiments up to the experimental works stage should be in the sole charge of a trained chemist or physicist, with works experience, responsible directly to the executive. That experimental work should not be under the direct control of the works. The head of the research department should take competent counsel from scientific sources, and from the heads of the various departments (manufacturing, costs, tests); committee meetings, lunch clubs and similar works institutions were well worth the time and money spent upon them. Wherever possible the results of research should be covered by patent rights, and where publication did not seriously damage commercial interests the results should be contributed to the common stock of scientific knowledge. No experimental work should be done in the manufacturing departments, except such as was required in starting a new machine or process, or in enlarging the production of a machine or process. Loss of production and leakage of knowledge were usually more costly than a special experimental machine.

In his second paper, on "Schemes for Co-operative Industrial Research," Mr. Rowell considered chiefly the following points:—That a laboratory or experimental station should be established on such a scale as to afford the employment of men of high grade for organisation and supervision of research; that the manufacturer might safely entrust all the details of his processes to the organisation; that discoveries made should be the property of the manufacturer initiating the experiment and bearing its cost; that these costs should be decidedly smaller, and the probability of success greater, than if the manufacturer had employed his own staff and laboratory. The suggestion had been made that the Government should unite with the learned societies and universities in providing research facilities for smaller works; Mr. Rowell feared that red tape, delay, high cost, and commercial inefficiency would make that combination useless. An example of the broadest type of technical combination was that of some 20 firms of electric incandescent lamp manufacturers in the United States. A group of manufacturers of sulphuric acid, tar products or pig-iron, might similarly pool investigation of raw materials, methods, improvement of products, disposal of by-products, outside competition, &c.; a full-size factory could be run in connection with the laboratory, as was done by the lamp manufacturers, in order to provide exact working data and to help to pay the cost of the research. At the other end of the scale was the Mellon Institute of Pittsburgh, a large institution in charge of an experienced director and a small permanent staff of specialists, erected and endowed by subscription, and fitted with private laboratories and experimental machinery. The manufacturer laid his problem before the director, who found him a graduate for the work at an agreed salary; it was then agreed to carry on the work for a maximum time, for a definite sum or part payment by results. This style of consulting chemist's laboratory on a large scale had done good work for several years.

Co-operation throughout a trade was no doubt profitable to all concerned, but British manufacturers did not seem likely to combine in this way for many years to come. Something less ambitious might have better chances of development. Tar producers and distillers could, *e.g.*, subscribe to institute a central laboratory and experimental works, for the purpose of agreeing, in the first instance, on tests and marketing conditions; close commercial agreement would be required for the working of the research department. Mr. Rowell went more fully into this question, and referred also to the antiquated methods still in use in the smelting and casting of iron, which had not shared the advance in the steel industry; pig-iron grades and foundry mixings should be standardised. The many non-ferrous metal works of the Birmingham district (melting, rolling, stamping works, &c.) all felt the need of expert advice as well, but practically none of them employed a chemist or metallurgist, because of the comparative cost.

Discoursing on "The Future of the Fine Chemical Industry," Dr. E. W. Mann, of the Charford Chemical Works, Birmingham, spoke in favour of the scheme proposed by Sir Thomas Barclay, the establishment of State research laboratories under joint manufacturing and academic control to work on industrial problems and to throw the results open under licence or royalty. That should answer, *e.g.*, for the tinctorial industry centred about Leeds and Huddersfield. As regards manufacture itself, certain manufactures could at present, with German competition eliminated, American competition severely handicapped, and the competition of the Far East only just perceptible, be profitably carried on in a small way. But what about the future? Was it possible to organise the fine chemical industry, or preferable to let the matter settle itself by the survival of the fittest? Efficiency might be tested or stimulated by an interchange of manufacturing costs, to be entrusted to a State department or to a trade association. The question of trained labour had not received sufficient attention. A tariff would probably be indispensable, for a time, at any rate; but the tariff should not be so high as to free the manufacturer from the stimulating effect of external competition, and it would have to be borne in mind that the product of one industry might be the raw material of another. Wholly unmanufactured raw material should presumably be free from duty.

In a paper on "Chemical Porcelain" Mr. Henry Watkins, of Messrs. James Macintyre and Sons, Burslem, referred to the history of porcelain, to its definition, uses, properties, the materials and manufacture, the methods of testing—not standardised, so far—and the successful efforts made since the outbreak of the war to make chemical porcelain in this country; Mr. Watkins pointed to his samples, and mentioned that a grant of 10,000*l.* had been made to the Technical School at Stoke-on-Trent for experimental work with hard paste porcelain and other research under the direction of Dr. Mellor. We commented on chemical porcelain and glass in our notes on the British Industries Fair, held at South Kensington last winter (see ENGINEERING, March 2, 1917, page 205).

"Some Observations on the Texture of Fireclays" were described by Messrs. W. C. Hancock and W. E. King, of the Imperial College of Science, South Kensington. The experiments were made on a typical Stourbridge fireclay in the raw and the fired conditions. The raw material, about 1,300 grammes, was first separated by elutriation in a Schoene apparatus into the usual four grades—clay, silt, fine sand, sand; the sand was further subdivided into grains of 0.04 mm. to 0.01 mm. and of 0.1 mm. to 0.2 mm., and the finest portion was further treated by the second sedimentation process of T. B. Wood, to which the whole material was also submitted. In this latter process the clay was stirred up with water in a graduated cylinder and allowed to stand for 24 hours; the sediment was then treated in the same way, and this was repeated until the supernatant liquid was clear after 24 hours. The proportion of particles obtained by the two processes (finest grain 0.0 mm. to 0.002 mm.) did not quite concord, and it was pointed out that when evaporation of the water was resorted to, serious contamination by the salts contained in the tap water would result. The finest particles were of the kaolinite formula $Al_2O_3 . 2SiO_2 . 2H_2O$. The particles were dried in air and, further, in an oven at 105 deg. C.; the losses in weight (from 15 per cent. to 21 per cent.) differed little in the two series; fraction No. 2 (grain from 0.002 mm. to 0.01 mm.) took up most water for moulding and shrank most, by 5.8 per cent., the shrinkage of the clay itself being 5.7 per cent.; whilst the next fraction, No. 3 (0.01 mm. to 0.025 mm.) took up least water and showed the smallest shrinkage, of 4 per cent. The particles were then fired at 1,200 deg. The shrinkages now varied between 8.8 per cent. and 12.4 per cent., and fraction 2 again showed the largest shrinkage, and fraction 3 the smallest, of 7.2 per cent. Further experiments are to decide whether these special properties of certain grain sizes will be found generally.

Speaking on "Sands used in Metallurgical Practice, with Comparative Notes on those Used in Glass Manufacture," Dr. P. G. H. Boswell, of the Imperial College of Science, mentioned that Birmingham had been sending its famous red moulding sand to all parts of the world. With respect to "British Resources of Sands for Glass-Making," he referred to his recent memoir (to be supplemented) published on behalf of the Ministry of Munitions. The same sand, he said, was often valuable for both glass-making and refractory work. Metallurgically, sands might be classified as used in moulding, in lining hearths and furnace bottoms, and in silica brick-making; moulding sands might be divided into sands with a natural bond and with an artificial bond. The required analytical tests were chemical, mechanical and mineralogical. Having referred to the constituents of sand, desirable or undesirable for different purposes, and given tables on sands from Leighton Buzzard, Lynn and Belgium for lining, and on sands from Derbyshire (three grades), East Anglia and Sussex for silica bricks, Professor Boswell passed to the connection between chemical and mechanical constitution. For moulding sands with natural bond chemical analysis was not much more useful than the analysis of a plum-pudding would be for the cook. Chemical analysis of each grade would be valuable. The coarse sand zone (quartz grains bearing thin pellicles of ferric oxide, very little feldspar and other minerals) of highly refractory silica had no bond; the bond was provided by clay and the water it absorbed, which made up the "glue"; the clay itself should be highly refractory, but the ideal alumina silicate (kaolin) had no great binding properties; fine sand and silt should be absent except for iron-casting and brass-moulding, which required smooth surfaces. Grading as to size of grain was very important. In the Triassic (Bunter) red sands of the Birmingham district (and also of Stourbridge, Wolverhampton, Runcorn, Doncaster, Belfast, &c.) the bonding clay or mud-grade was not a hydrated aluminium silicate, but ferric oxide, each grain of quartz being surrounded by a pellicle of oxide which held a film of water. Many sands, in fact, held 10 per cent. or 12 per cent. of water without being wet, and they were good for iron and brass casting, and also for steel when temperatures were not very high and conditions not exacting.

As regards mineral composition, zircon (a silicate), rutile (TiO_2), limonite ($2Fe_2O_3 . 3H_2O$), ilmenite ($FeTiO_3$), were very harmful in glass-making; feldspar was advantageous there, but harmful in refractories, where calcium and magnesium carbonates (dolomites) were also very objectionable. In these analyses the geologists made use of special methods, density determinations (floating in bromoform, &c.) and the microscope, rather than of chemical methods. Crushed vein-quartz and quartzite and crushed sandstones were not liked by glass-makers; there might be allotropic low-temperature forms of silica of somewhat different properties. There were also different quartz minerals, opal, chalcedony, &c.; "allogenic" minerals were derived from the breaking down of older rocks, "anthigenic" minerals were formed after the sand had been laid down. Colloidal gelatinous silica made an important bond. Much iron oxide in sand came from ferruginous minerals; glauconite was an iron-potassium-aluminium silicate, and some of the best steel-moulding sand (Belgian red and yellow, Cornish red), which had a velvety grip and a very strong bond, was associated with glauconite-bearing deposits. Kaolin was also a decomposition product, of feldspar. Dr. Boswell also referred to abrasives. As the Bessemer and Tropenas processes were giving way to the open-hearth processes, the demand for high-temperature steel sands was increasing.

In his paper on "The Calorific Value of Industrial Gaseous Fuel," Mr. W. J. Pickering, of the City Gas Department, Birmingham, dealt with the calorimetric units and in detail with the apparatus and methods in use over here for testing gas; statistical and comparative figures concerning various fuels were not given. On the Continent, Mr. Pickering stated, the unit of heat was the large calorie (Cal. or K.), indicating the amount of heat required to raise 1 kg. of water 1 deg. C. The British thermal unit was the amount of heat required to raise 1 lb. of water 1 deg. F., but the Metropolitan Gas Referees defined the calorie as the heat which would raise the temperature of a litre of water 1 deg. C., and this was generally accepted in this country. [These definitions might profitably have been extended a little.] The units of volume—on the Continent 1 cub. m., in this country 1 cub. ft. at 60 deg. F. and 30 in. barometer—were also different. Further, "gross" and "net" calorific values were distinguished. When the combustion of gas took place under conditions such that the water formed from the hydrogen present in the gas was condensed, the latent heat of vaporisation of the whole of the water formed was included in the heating value of the gas; the gross calorific value was then obtained. When the latent heat of the water vapour condensed, together with the heat given up by the condensed water in cooling from 100 deg. C. to the atmospheric temperature, was deducted from the gross value, the

"conventional net" value, or the "net A" value, was obtained; when only the latent heat of vaporisation was deducted, the "net B" value resulted, representing the "true thermodynamic net" value. The difference between these two net values was about 1 per cent. for ordinary coal gas. Up to the present time the conventional net value had generally been adopted. Recently, however, the gross or, more correctly, the total heating value of a gas was preferred, because the "total heat" capable of development from a gas, when burned under correct conditions, was the real calorific value. But the gross value given by many calorimeters was not the real total heating value, owing to the effect of certain atmospheric conditions (low humidity, &c.). Generally speaking, gross value was identical with observed value, so that "total heat" should be adopted in preference to "gross value." For industrial purposes it was sufficiently precise to define the "total heating value" as the number of British thermal units produced by the combustion, at constant pressure, of the amount of gas which would occupy the volume of 1 cub. ft. at 60 deg. F., if saturated with water vapour and under a pressure equivalent to 30 in. of mercury at 32 deg. F. and under standard gravity, with air of the same temperature and pressure as the gas, when the products of combustion were cooled to the initial temperature of the air and gas, and when the water formed by combustion was condensed to the liquid stage.

The calorimeters in use were generally of the flow type, instruments in which the gas was constantly burning and through which water was flowing, both at rates to be measured accurately. Flow calorimeters were of two classes: (1) those in which the paths of travel of the products of combustion and of the water were relatively short and parallel; and (2) those in which the water streamed through a long spiral round which the combustion products passed slowly. The calorimeter in use at Birmingham was of class (1), the standard instrument of the Metropolitan Gas Referees, the Boys instrument, of class (2). Up to the commencement of the war the Junker calorimeter had been the technical instrument in Birmingham; when the supply of these calorimeters ceased an improved instrument of this type had been worked out in the Windsor-street works under the supervision of Mr. J. Turnbull, superintendent of the meter shops, and had soon been supplied at a lower price than that previously paid. In this instrument tinned copper was the chief material, and slightly heavier gauge metal was used in the internal parts. Mr. Pickering proceeded to describe in detail this instrument and that of Professor Boys, as well as the additional apparatus required, and then discussed the methods of testing and errors to be guarded against. He also referred to the instructions for determining the heating value of gas as recently elaborated by the Park Municipal Lighting Laboratory (approved by the Prefect of the Seine). He finally came to recording calorimeters which, though not entirely trustworthy so far, were useful as guides to the fluctuations in the quality of the gas on a works "stream." Of these net-value instruments the Beasley Recorder, made by Messrs. H. Parkinson and W. and B. Cowan, Limited, of Birmingham, was the most satisfactory; a description was added. A calorimeter giving a continuous record of "total heating value" would be still more useful, though more expensive than a net-value instrument, and he hoped that it would soon be made in this country; so far the only gross-value instrument had come from Germany.

In his notes on "The Analysis of Some Aluminium Alloys" Mr. J. H. Stansbie described rapid analytical methods for the manufacturer who does not wish to know the constituents of his alloys within less than 0.1 per cent., since he cannot hope to get within closer limits in making the alloys. The elements to be determined, Mr. Stansbie explained, were zinc, copper, manganese, nickel, magnesium, tin, lead, iron, silicon; the last three were mostly accidental impurities, but Pb and Fe might have been added. In preparing his solutions he started from bulk sawings, obtained by means of a moderately fine metal saw, rather than from turnings or borings. To test for Si, Cu, Mn, he dissolved 1 gramme of the sawings in sulphuric and nitric acids, to which hydrochloric acid was subsequently added, the copper being deposited electrolytically and the manganese found by titration. In the more general analysis he dissolved 2 grammes of the alloy in caustic soda, which would dissolve Al and Zn [the latter deposited electrolytically—not an accurate method unless used with special precaution], and treated the residue with nitric acid. For the determination of nickel he recommended the method recently worked out by the Rev. F. G. Belton, which relied upon the precipitation of nickel by the dimethyl glyoxime [of Tschugaëv].

"Cartridge Brass," Dr. H. W. Brownsdon pointed out in his paper, could only have the required malleability, ductility and strength if the materials—65 per cent. to 75 per cent. of copper, the rest zinc—were of high purity, over 99.9 per cent. The brass should not contain more than 0.045 per cent. of iron and 0.025 per cent. of lead, with traces of other metals. The two metals were melted in crucibles, together with some clean, heavy scrap, and, thoroughly mixed, poured into cast-iron ingot moulds, to be rolled down to strip, which was annealed at 650 deg. C.; thicker strip might be annealed at 680 deg. and 700 deg. to save time; the annealing took three-quarters of an hour, but small articles might be annealed in five minutes in rotary gas muffles. The mechanical properties of the cast ingot, hard rolled strip, and annealed strip were respectively: yield-point, 6, 20 and more, 6 tons; tensile strength, 16, 30 to 40, 20 to 23 tons; elongation, 60 to 70, 10 to 15, 65 to 75 per cent.; Brinell hardness, 60, 150 to 200, 60. The enormously increased demand for cartridges had not led to any notable development in the methods, but the composition, casting, mechanical operations and annealing all required very close attention. What might be recognised as theoretically the best method might prove too slow in practice. The annealing in particular demanded experienced labour, difficult to provide at present. Several per cent. of the material might be lost through oxidation, volatilisation and pickling; annealing in a non-oxidising atmosphere would reduce the losses; clean (against dirty) annealing had become much more important since sulphuric acid was no longer available for pickling, for which nitre cake had to be used. The annealing should be checked by pyrometer, microscope and hardness tests, and to ensure uniform products generally there should be analytical control of the metals going into the pot and of the castings, and correct distribution of mechanical work at the various stages of manufacture. The strip thickness should be uniform within 0.001 in., and careful inspection was necessary to remove local flaws. Cases other than those for small arms, unless seriously damaged mechanically, might be re-formed to size and re-used. Small-arms cases, unfortunately, were deteriorated by the firing, and could not even be utilised as scrap mostly. The trouble was caused by the mercury and antimony salts in the percussion-cap ingredients; the mercury weakened the brass and the antimony interfered with the remelting. Repeated washing of the fired cases in suitable solutions could do some good, but antimony was generally found in the ingots afterwards. The re-utilisation of this scrap was a big problem at present; though there would always be a demand for high-quality cartridge brass, however, the industry would diminish in volume, of course. Dr. Brownsdon concluded by expressing his thanks for assistance in preparing his papers to Mr. R. A. E. Payne and Mr. H. Rogers, general manager and works manager of the King's Norton Metal Company, whose works were among those visited during the meeting.

"Economy of Acids in Metal Trades." This paper, by Mr. E. Kilburn Scott, dealt in the first part with nitre cake, the acid sodium sulphate, $NaHSO_4$ in its pure state, which is an intermediate product of the sodium sulphate (Glauber salt) manufacture and a by-product of the manufacture of nitric acid. By the latter process, Mr. Scott stated, nitre cake was now produced in very large quantities, and then contained, in addition to about 63 per cent. of neutral sulphate, Na_2SO_4, $10H_2O$, from 30 per cent. to 35 per cent. of free sulphuric acid, 1 per cent. or 2 per cent. of nitric acid, moisture and small quantities of other salts. The freshly-made cake was free of moisture, but it slowly absorbed moisture even when under cover. Before the war the cake had been used for making Glauber salt, hydrochloric acid, and salt cake, also for glass works and as manure, unless simply treated as waste. At present it was largely used as a substitute for sulphuric acid in the textile industry (grease extraction and refining, stripping colour from rags in making shoddy, extracting cotton from mixed fabrics for shoddy, dyeing and bleaching), in binding ammoniate to sulphate, and particularly in metal pickling. But the nitre cake was awkward to handle, and the use of the solution, also known as "sulphate acid," was not so simple as that of sulphuric acid. The nitre cake, when moist or dissolved, attacked cloth, wood, iron, and house foundations, unless they were asphalted or consisted of stone flagging with asphalt joints. When a hot solution was allowed to stand the Glauber salt crystallised out and broke the carboys or settled in the boshes—from which it should be removed by shovels—and on the articles to be pickled. There were hence many complaints when the nitre cake was first tried in the metal trade. Owing to the tendency to crystallising the strength—the acid strength is wanted—could not be determined by hydrometer (density) tests, and tubes and articles with small holes got clogged. Mr. Scott described various methods in use for "brewing" or dissolving the cake, *e.g.*, in separate boshes, at a higher level than the pickling bosh, by the aid of steam and of baffles, or in tanks with an intermediate platform of wooden slats. One Birmingham firm had built brewing tanks capable of dealing with canal-boat loads of 30 tons; the walls were of acid-proof brick and lined with lead. Iron tubes and malleable castings pickled in the cake looked bluish rather than brownish; the impurities in the cake were not unimportant; some firms added white arsenic to the pickle for checking the action of the acid after removing the scale. The nitre cake solution was not very effective for removing borax from brazed tubes, and although 3*l.* worth of the cake might do as much as 7*l.* worth of sulphuric acid, it was doubtful whether the cake would offer advantages in normal times.

Passing in his second part to the use of other acids, including "aquafortis" (a mixture of sulphuric and nitric acids), Mr. K. Scott remarked that the scarcity of sulphuric acid had shown manufacturers that they could save a great deal of the acid they had formerly used or dispense with it altogether. For instance, brass buttons had been finished by barrelling, first in scouring barrels filled with granite chips and water, then in burnishing barrels containing steel bicycle balls and Hudson's soap and water, and finally in drying barrels containing beech sawdust. Pickle should be hot or act on the hot metal. By dropping the cartridge cases direct from an automatic muffle into concrete vats lined with lead containing weak pickle of only 1 per cent. a Birmingham firm effected a very considerable saving in acid. The spent pickle should not be allowed to be run to waste in the sewers, where it was a nuisance; even common metals might be recovered, and there would be an opening for a central pickling plant in places like Birmingham. In hollow-ware pickling 50 lb. were often lost per ton of articles pickled.

This hollow-ware pickling was generally done in hydrochloric acid, which attacked steel tubes (the metal) less than the sulphuric acid did; in Birmingham from 1¼ to 2½ carboys of acid were used in excess of what was required for pickling the sheet metal in South Wales. The hydrochloric acid was preferably used cold, the action being then more uniform than with steam introduction; for aquafortis pickling Mr. Scott recommended a hot pickle, however; the hydrochloric-acid boshes were lined with boards, a mixture of tar and pitch being run between the boards and planks.

Considerable economy in acid was possible by sand blasting. The sand-blast room had a glass roof with ventilator and a perforated steel grid floor, through which the abrasive fell into a hopper; a cyclone separator afterwards separated dust and abrasive; the operator working inside the room was provided with a helmet. There were also barrel sand-blast plants and chamber plants; in the latter case the operator stood outside the chamber, behind a window, directing the blast by putting his arms through openings. For cleaning shelves vertical sand blasts were used.

Electrolytic pickling had been successful abroad, but hardly over here. The electrolyte was brine with 1 per cent. of hydrochloric acid; continuous and alternating currents might be used—Mr. Scott said that the action of the alternating current was not clear, but the effects were explained years ago; reflectors in such baths were put in a crate. Reverting, finally, to the many different annealing furnaces in use, Mr. Scott considered most of them bad, in spite of extravagant claims made. In one case he had found an ordinary coal-fired muffle and a Bonecourt muffle working side by side; in the former the loss in annealing and cleaning copper had amounted to 0.7*4*, in the latter to 0.1*8* per cent. Of furnaces working in neutral atmospheres, he mentioned the non-scaling muffle of Bates and Peard, for non-ferrous metals. The articles entered the airtight chamber, which was fired with gas, oil, coal, &c., on a chain belt drawn through a water seal and left through another water seal. The similar muffle of Vaughan Hughes, also for non-ferrous metals, was filled with superheated steam. Mr. Edmund Howle was interested in a clean annealing furnace which used an atmosphere of purified producer gas, the hydrogen of which reduced the iron oxide to iron. The metals passed through a hot muffle and then through a cooling chamber charged with the same gas.

(To be continued.)

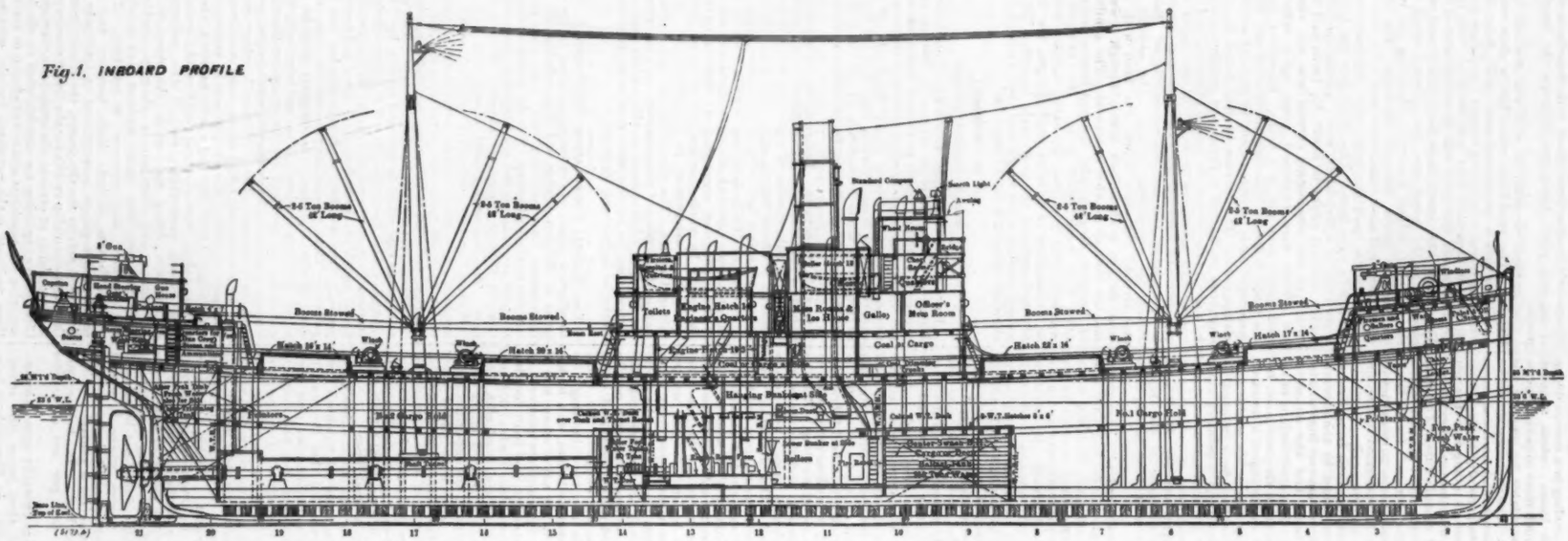
EXPORTS TO NEUTRAL EUROPEAN COUNTRIES.—The Board of Trade desire to suggest to British exporters engaged in sending goods to neutral European countries the desirability of concluding their contracts on a f.o.b. (instead of a c.i.f.) basis where the goods can only be exported under licence, having regard to the fact that it is frequently made a condition of the issue of such a licence that the goods must be carried in neutral vessels.

GAS MANUFACTURE.—Referring to the appeal recently issued by the Controller of Coal Mines to the gas industry, urging the substitution of water-gas for coal-gas to the greatest practical extent, with a view to effecting coal economy, certain factors have since arisen which require a reversal of this policy, and with a view to securing the maximum quantity of coal-tar products, the Minister of Munitions now urges that all carbonising plants at gas works be worked to the fullest extent, before any water-gas, carburetted or uncarburetted, is manufactured at all. The Controller of Coal Mines, who is aware of the altered circumstance, will co-operate with the Ministry of Munitions in this matter, and will give instructions for all necessary coal to be delivered to gas works for carbonising purposes.

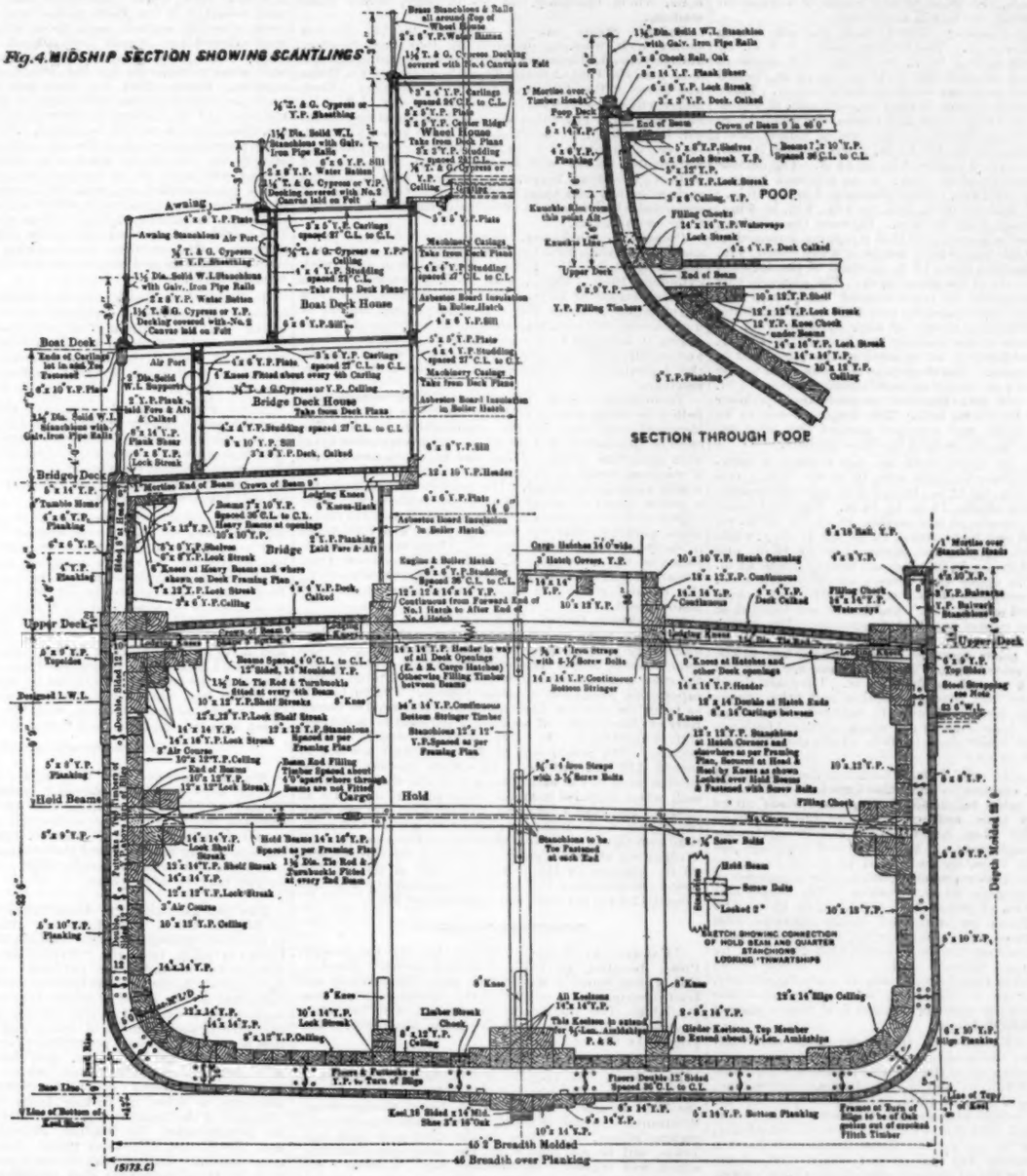
THE HALIFAX CORPORATION SUB-STATIONS.—In order to afford a supply of continuous current to the outlying areas of Hebden Bridge and Hipperholme the Halifax Corporation have recently laid down two converting stations in these districts. For the electrical equipments of these sub-stations the contract was entrusted to the General Electric Company, Limited, Witton, Birmingham. The converting unit chosen was the 250-kw. "Witton" rotary converter, together with an oil-insulated, air-cooled transformer taking in three-phase power at 6,600 volts and generating at 550 volts for traction and 220–0–220 volts for lighting, the rotary converters serving the double purpose. The incoming feeders are controlled in each sub-station by "Witton" mistake-proof switchboards. The Hipperholme sub-station, having two converting units, has two incoming feeder panels on the high-tension board and two machine panels. That at Hebden Bridge has but one machine panel. These installations exhibit the compactness of the "Witton" boiler-plate cubicle arrangement for sub-stations. The cubicles eliminate the possibility of accident to the operator through inadvertence, a thorough interlocking arrangement preventing such occurrences. The "Witton" rotary converters run at a speed of 1,000 r.p.m., and are designed for reactance control. For the purpose of keeping constant the voltage across the three-wire network, the neutral wire is taken from the star-point of the transformers. The rotary converters are of the self-synchronising pattern, being run up to the speed by a starting motor and switched in through choking coils. They fall into step easily without any synchronising and without any reversal of polarity. The low-tension boards include both traction and lighting panels, and a simple arrangement of interlocks between the liquid starter for the motor, the circuit-breaker and the short-circuiting switch for the liquid starter precludes any possibility of error in the sequence of the operations. Change-over switches are also included on the board for applying the machines either to lighting or traction, and these switches make provision for the opening of the neutral connection when the machines are required for the latter purpose.

UNITED STATES GOVERNMENT STANDARD WOODEN STEAMSHIP.

Fig. 1. INBOARD PROFILE


5" Gun
24 Ton Booms 65' Long
24 Ton Booms 18' Long
Search Light
Awning
Booms Stowed
Hatch 16' x 14'
Winch
Hatch 20' x 14'
Toilets
Engine Hatch 16' Athwartships
Mess Room & Ice Room
Galley
Officer's Mess Room
Coal or Cargo
Hatch 22' x 16'
Hatch 17' x 14'
Windlass
Hanging Ventilator Bulk
Cofferdam
Cofferdam W.T. Bulkhead
Cofferdam W.T. Bulkhead
Cofferdam W.T. Bulkhead

UNITED STATES GOVERNMENT STANDARD WOODEN STEAMSHIP.


SECTION THROUGH POOP
Wheel House
Boat Deck House
Bridge Deck House
Bridge
Hold
Cargo
Awning
Boat Deck
Bridge Deck
Upper Deck
Hold Beams
Engine & Boiler Hatch
Cargo Hatches 14'0" wide
Lodging Knees
Beams 7" x 10" Y.P. Spaced 36" C.L. to C.L.
Asbestos Board Insulation in Boiler Hatch
Machinery Casings Take from Deck Plans
Bridge Deck House Take from Deck Plans
Boat Deck House Take from Deck Plans
Awning Stanchions Air Port
Knees Fitted about every 4th Carling
Air Port
Air Course
Ventilators
Tumble Home
Flanking
Stanking
Tuyeres
Load W.L.
Ballast W.L.
Double Sided 12" Keel
Keel 15" Sided x 14" Mld.
Shoe 5" x 16" Oak
Floors & Futtocks of Y.P. to Turn of Bilge
Floors Double 12" Sided Spaced 36" C.L. to C.L.
Frames of Turn of Bilge to be of Oak grown out of crooked Pitch Timber
Line of Top of Keel
Line of Bottom of Keel Rise
Rise of Floor
Base Line
45'2" Breadth Moulded
46' Breadth over Planking
(5173.C)
Fig. 4. MIDSHIP SECTION SHOWING SCANTLINGS
SKETCH SHOWING CONNECTION OF HOLD BEAM AND QUARTER STANCHIONS LOOKING TOWARDS STERN
Depth Moulded 28'

PRINCIPAL DIMENSIONS OF THE SHIP.

Length over all	281 ft. 6 in.
Length between perpendiculars	268 ft.
Beam, over planking	46 ft.
Depth, moulded at side of upper deck	26 ft.
Load draught from bottom of keel shoe	23 ft. 6 in.
Total estimated deadweight	3,500 long tons
Sea speed, loaded	10 knots
Indicated horse-power	1,400
Armament	Two 3-in. guns

ESTIMATED WEIGHTS.

	Yellow Pine Ship. Long tons	Douglas Fir Ship. Long tons
Wood in hull	1677.0	1827.0
Fastenings	142.4	145.7
Anchors and cables	31.4	31.4
Paint and caulking	10.0	10.0
Forgings and castings	35.0	35.0
Hull piping and machinery	50.0	50.0
Two guns	7.0	7.0
Miscellaneous outfit	27.2	27.9
Total hull weight	1980.0	2134.0
Propelling machinery	275.0	275.0
Deadweight	3625.0	3421.0
Displacement at 23' 6" S.W.	5880.0	5830.0

These figures for the wood hull are based on bills of material after deducting scrap, and for lumber of about 18 per cent. moisture. Green lumber will weigh about 12 per cent. more.

either dense southern yellow pine as graded by the Southern Pine Association, or Douglas fir. Specifications for both materials are given, although the following applies to yellow pine, the scantlings for which are shown on the midship section, Fig. 4. The entire hull will be of yellow pine, except the stern post, rudder post, rudder stock, horn timber, shaft log and keel shoe, which will be of white oak. Wood knees will be of hackmatack or oak. Treenails will be of locust or split oak. Joiner sheathing and decks, where specified, will be of cypress.

Hull Construction.—The keel is of yellow pine, 16 in. by 14 in., to which is fitted a shoe of white oak, 3 in. thick and 16 in. wide. The stem, of yellow pine, is sided 16 in. and moulded 20 in. The apron, of yellow pine, is 16 in. by 16 in., backed up with a second apron of the same size. Both aprons are in one length, extending to the forecastle deck. The stem grip is of white oak, sided the same as the stem. The knight heads are of yellow pine, sided 20 in. and moulded the same as the frames, fayed up to inside the apron. The forward deadwood and knee are of yellow pine, sided 16 in. and moulded 18 in., extending from through the floors forward for receiving the heels of the cant frames. The knee is of hackmatack or oak, connecting the keel to the stem grip, and apron 16 in., sided with long arms. The forward deadwoods are of yellow pine, sided 16 in., bedded in between the top keelson and apron. The outside and inside stern posts are of white oak, sided 28 in., in way of the shaft log, 16 in. above the keel and at head moulded 24 in. The lower end of each post is tapered to the siding of the keel, and to have a tenon 5 in. by 12 in. by 14 in. fastened with two 1¼-in. treenails. Each stern post extends to the upper deck and is fastened to the deck beams. The after-side of the outer post is rounded out above and below the stern bush casting for an easy flow of the water. The shaft log is of white oak built up in four pieces, 14 in. by 14 in., bored out to receive the stern tube. The after deadwood and knee are of yellow pine, sided 16 in. and moulded 18 in., extending from through the frame floor aft to the stern post for receiving the heels of the cant frames. The after deadwoods are of yellow pine, sided 16 in., bedded in between the top of the shaft log and inner stern post. The rudder post is of white oak, sided 16 in., moulded 18 in., to have a tenon in the keel 5 in. by 12 in. by 14 in., fastened with two 1¼-in. treenails.

Framing.—The rudder stock is of selected best white oak finished 18 in. diameter. The rudder blade is built up of yellow pine, tapered to 14 in. at the after edge. The main frames are double-sawed, of yellow pine. The bilge frames are worked out of crooked oak, straight fir or wide yellow pine, sided 12 in., moulded on keel 18 in., at turn of bilge 16 in., at top of bilge 12 in., at upper deck 10 in., at bridge, forecastle and poop 8 in., also at bulwark rail 8 in. The frames are spaced 36 in., centre to centre. In way of the bridge, forecastle and poop the frames continue up double. There are eight main keelsons of yellow pine, 14 in. by 14 in., and on each side girder keelsons of yellow pine arranged as shown on the

midship section, the first strake 10 in. by 14 in., and the second and third strakes 8 in. by 14 in. The first and second strakes are worked the full length between the peak bulkheads, the third or top strake is worked for about three-fifths the length amidships.

Ceiling and Planking.—The bottom and side ceiling is all of yellow pine. The bottom ceiling is 8 in. by 12 in., the side ceiling 10 in. by 12 in. One strake of the side ceiling on each side is 12 in. by 12 in., locked over the frames, as shown on the midship section. There are three strakes of bilge ceiling on each side, of yellow pine, 14 in. by 14 in., with five strakes between, 12 in. by 14 in. The garboard strakes are of yellow pine; the first strake, 10 in. by 14 in.; the second strake, 8 in. by 14 in.; third strake, 6 in. by 14 in. The outside planking, also of yellow pine, is as follows: bottom planking, 5 in. by 14 in.; bilge planking, 6 in. by 10 in.; side planking, 5 in. by 10 in., 5 in. by 9 in., 5 in. by 8 in.; topside planking, 6 in. by 9 in. Between the planking and the frames is a system of iron strapping arranged as follows:—At the upper deck beams is a top chord, 8 in. by ½ in., extending from 12 ft. forward of the forward hatch to 12 ft. aft of the after hatch. The plates in this chord are connected by triple-riveted butt straps and are fastened to each frame by two 1-in. by 10-in. bolts, staggered. Diagonal straps of 4-in. by ½-in. iron, let into the outside of the frames, and inclined at 45 deg. each way, are fitted so as to meet at the top chord in every frame space. The diagonals are connected to the chord by two ⅞-in. rivets at each crossing by one 1-in. rivet. They are also fastened to each frame timber by one 1-in. by 10-in. bolt. The diagonals are to be carried well down and wrapped around the bilge far enough to overlap the ends of the floor timbers.

Decks.—At the upper deck are two strakes of deck-beam shelf timbers on each side, 10 in. by 12 in.; one lock strake, 12 in. by 12 in., locked 2 in. over the beams; and one bosom strake, 14 in. by 14 in. The hold beam shelf timbers consist of one strake, 10 in. by 12 in. on each side, and one lock strake, 12 in. by 12 in.; while below the hold beams is one strake 12 in. by 14 in., one lock strake 14 in. by 14 in., and one bosom strake 14 in. by 14 in. The upper deck beams are of yellow pine, sided 12 in., moulded 14 in., worked with 9-in. crown shape 5 in. and spring, 4 in. The beams are doubled at the hatch and engine and boiler openings. The beams are spaced about 4 ft., centre to centre. In way of hatches and other openings carlin beams are fitted, sided 8 in., moulded 14 in. The hold beams are of yellow pine, sided 14 in. and moulded 16 in. They are fitted throughout the hull between hatches and other upper deck openings, spaced about 4 ft. centres. Beam and filling timbers, spaced about 4 ft. apart, are fitted between the upper and lower shelf timbers where through-hold beams are not fitted.

Stanchions.—In way of hatch coamings there are fitted on each side, continuous from the forecastle-head bulkhead to the poop bulkhead, deck girders made up of two 14-in. by 14-in. and one 12-in. by 12-in. timbers, with 14-in. by 14-in. hatch header and filling timber between through beams. The hatch-end coamings are made up with 14-in. by 14-in. and 12-in. by 12-in. toe fitted into the girder timbers, forming the remainder of the hatch coamings, 10 in. by 10 in. The centre and wing stanchions, of yellow pine, are 12 in. by 12 in. The centre stanchions are connected to the keelsons with 8-in. wood knees, one stanchion in way of each hold beam, connected at the hold beam with two ⅞-in. by 4-in. iron straps fastened with six ⅞-in. screw bolts; also connected to upper deck beams in a similar manner. Iron tie-rods, 1¼ in. diameter, with turnbuckles, are fitted in way of the upper beams and hold beams, spaced about every fourth beam.

Bulkheads.—Forward of the boiler-room bulkhead, extending into the hold, is a deep water tank for water ballast, extending up to the line of the hold beams. The bulkhead is of 3-in. by 8-in. double diagonal yellow pine, with studding of 8-in. by 12-in. yellow pine spaced 24 in. apart. The centre fore-and-aft bulkhead is of yellow pine, 6 in. thick, with 8-in. by 12-in. yellow pine studding, spaced about 30 in. apart. These tanks will have a capacity of about 350 tons of salt water. Aft of the engine-room bulkhead on each side of the thrust recess, extending up to the line of the hold beams, are tanks for boiler feed having a capacity of about 80 tons of fresh water. The tanks are constructed in the same manner as the deep water tanks. The forepeak tank is arranged for carrying fresh water. The after peak is arranged for carrying fresh water for boiler feed and for salt water for trimming purposes. Between the engine and fire-room is a steel screen bulkhead built of plating, $\frac{7}{16}$-in. thick, stiffened with 2½-in. by 2½-in. by ½-in. angles, spaced about 24 in. apart. The bulkhead is to fit partly around the boilers and to have a hinged door for passage from the engine to fire-room.

Fastenings.—In the matter of fastenings, the following is provided in the specification:—All fastenings to be equal to the requirements of the American Bureau of Shipping and, in addition, in accordance with the following plans of fastenings: All nail, spike and bolt iron fastenings to be galvanised, and all clinch rings galvanised. Screw-bolt fastenings to be used where necessary. All bolt-iron fastenings through yellow pine or fir wood for bolts up to 24 in. in length to be driven with about ¼ in. drift. For bolts exceeding 24 in. in length, driven with drift of $\frac{1}{16}$ in.; for bolts through oak, $\frac{1}{8}$ in. drift. All bolts driven over clinch rings to be well headed and blunt, or drift bolts pointed where necessary. All bolt fastenings in outside planking, waterways, plankshears, rails and weather bulkheads, and all bolt or spike fastenings in weather deck to be plugged with white or yellow pine plugs dipped in white lead paint. The treenails to be of good grade split locust, oak or other approved wood, and wedged on both ends across the grain of the wood through which they are driven. As many treenails as possible, at least one-half, driven through and wedged on both ends. Tie-rods and screw bolts, where necessary, set up in large, heavy plate washers.

Boilers.—Steam will be furnished at 190 lb. per square inch working pressure by two three-furnace, marine type, coal-burning boilers, constructed in accordance with the United States Steamboat Inspection Rules and those of the American Bureau of Shipping. Each boiler will be 14 ft. 6 in. inside diameter and 11 ft. 2 in. long over all. The total effective boiler-heating surface will be 4,500 sq. ft., and the total grate area 105 sq. ft. As an alternative for Scotch boilers the following water-tube boilers will be acceptable: Babcock and Wilcox, Howden, Yarrow or Mosher, with a heating surface of not less than 5,000 sq. ft. Other types of water-tube boilers will be considered, the heating surface to be as approved.

Propelling Machinery, Single-Screw Ship.—For a single-screw ship, fitted with a reciprocating engine, the main engine will be of the triple-expansion type, with cylinders 19-in., 32½-in. and 54-in. diameter, with a common stroke of 42 in. The engine will be built for a piston speed of about 630 ft. per minute and capable of maintaining 90 r.p.m. with the ship at load draught. The engine is designed to develop 1,400 i.h.p. when working under full boiler pressure, with no live steam passing the high-pressure cylinder and no live steam in the receivers.

Twin-Screw Vessels.—In the twin-screw vessels propelled by reciprocating engines the boiler plant will be identical with that for the single-screw vessels. The engines themselves will be of the triple-expansion type, with cylinders 14½-in., 25-in. and 42-in. diameter, with a common stroke of 26 in. The engines will turn outboard when going ahead. The engines will be built for a piston speed of about 600 ft. per minute, and each engine will be capable of developing 900 i.h.p. at 133 r.p.m. when working under full boiler pressure with live steam in the receivers, and 700 i.h.p. at 115 r.p.m., with no live steam in the receivers. Engines of different size from the above will be accepted if they are capable of meeting the desired conditions of indicated horse-power and piston speed.

Single-Screw Geared Turbines.—For a single-screw, geared turbine, coal-burning ship the propelling machinery is to be built to conform with and meet the requirements of the American Bureau of Shipping and the rules and inspection prescribed by the United States supervising inspectors of steam vessels. The turbine is to be of the General Electric, Westinghouse, De Laval, Kerr or other approved make, of 1,400 shaft horse-power, and connected to the main shaft by double-helical gearing. The revolutions of the main shaft are not to exceed 110 per minute. An astern turbine will be incorporated in the same casing with the ahead turbine, and, when supplied with the same amount of steam as used for full load conditions, will develop not less than two-thirds of the full power ahead torque on not more than two-thirds of the full speed revolutions per minute. With steam at 180 lb. gauge pressure at the throttle and 28 in. vacuum in the condenser, and at normal full power revolutions, the steam consumption will not exceed 12.5 lb. per shaft horse-power per hour.

"FARMING BY MOTOR."—Under this title the Temple Press, Limited, of 7–15, Rosebery-avenue, London, E.C. 4, has issued a book which gives illustrations and brief descriptions of nearly all the farming motors now available. The number is surprising, and intending buyers will find this book of great assistance. The price is 1*s.* 6*d.* net.

PERSONAL.—The transfer of the offices of the Department of Scientific and Industrial Research (including the Fuel Research Board) to 15, Great George-street, Westminster, which is nearly opposite the department's present offices, took place on the 23rd and 24th inst. There will be no change in the telegraphic address, which will remain "Resciendus, Parl., London," and the official telephone number will be, as before, Victoria 7940 (2 lines).—Palace Chambers having been requisitioned by the Government for the accommodation of the staff of the Ministry of Food, Messrs. C. P. Sandberg advise us that they have taken new offices at Princes' Mansions, 70, Victoria-street, Westminster, London, S.W. 1, which will be their address from August 1 until further notice. Their telegraphic address and telephone number remain the same.

ELECTRIC CURRENT RECTIFICATION BY AIR BLASTS.—A partial current rectification is obtained when alternating currents flow from a point to a disc. This has long been known. In *The Physical Review* of June, 1917, E. R. Wolcott and C. J. Erickson describe a simple air-blast device for the complete rectification of strong currents. The point electrode is mounted axially in a tube, and may or may not project through the tube aperture, of 4 mm. diameter; when the end projects the tube may be made of metal, otherwise the tube must be of insulating material. In one case mentioned the disc normal to the tube axis had a diameter of 10 cm.; the disc must be large enough to prevent sparks from jumping to the edge of the disc; the distance between the point (projecting from the tube) and the disc was 1.76 cm.; the device rectified currents at 40,000 volts, and even 350 kilovolts, at 500 cycles maximum from a 2-kw. transformer. The rectified discharge is snappy, particularly when the electrode (of iron, brass or aluminium) does not project from the tube. The device, which is patented, does not operate well at low voltages.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—Quietness has reigned in the steel industry in the West of Scotland during the past week, the only workers being those whose services were requisitioned for urgent Government orders and the repair staffs making good the ravages to machinery and plant occasioned by the strain of the past few months. Every effort has been put forth to get as much as possible of this repair work accomplished within the limits of the holiday, in order to permit of a general start being made at the beginning of the week. Little or no attempt was made to resume operations on Monday, but by the end of the week it is expected that every worker will again be at his and her post. The break was a much-needed one, and the Government approval of the Fair Holidays greatly added to the satisfaction of the many thousands of busy toilers who were set free. It is confidently expected that there will be an increase in prices in the immediate future, owing to the continued scarcity of all raw and semi-finished material. Meantime, rates are firm.

Malleable Iron Trade.—In the malleable iron trade, beyond the necessary overhauling of all machinery, which has been running so continuously for many months now, nothing in the nature of work has been attempted during the holiday recess. Makers' order books are well filled, however, and a busy time is in store for everyone.

Scotch Pig-Iron Trade.—Perhaps the pig-iron trade was the only industry which made any serious attempt to keep things going on the usual lines during the Fair Holidays, although, naturally, all was not plain sailing—there were decided drawbacks to this. In a few days, however, the threads will be taken up once more, and all will run smoothly again.

Further Advance of Wages.—After going very fully into the matter of wages in the engineering, shipbuilding and iron-foundry industries, the Committee on Production has just issued its report awarding a further advance to all workmen employed by members of the Engineering Employers' Federation—an advance of 3*s.* per week to all men of 17 years and over, as from and including August 1, 1917. Boys, youths and apprentices under 17 years of age are to receive 1*s.* 6*d.* per week increase, and a further advance of 1*s.* 6*d.* upon attaining their eighteenth birthday. It is pointed out by the committee that these awards are additional to those decided upon in March last, when the matter of wages in relation to the present abnormal times was first taken up, and affect men belonging to 45 different trades unions.

SIAM'S OUTPUT OF WOLFRAM.—Siam's wolfram output, says *Indian Engineering*, increased from 4,517 piculs (602,267 lb.) in the fiscal year 1915 to 7,128 piculs (950,400 lb.) in 1916, the entire amount having been mined in the district of Nakawn Sritamarat, in the Siamese Malay States, where the producing area has also increased, and with the present high prices a still larger output may be anticipated.

THE DEVELOPMENT OF AGRICULTURAL ENGINEERING IN BRITISH INDIA.—The following information, relative to the development of agricultural engineering in British India, is taken from the "Report on the Progress of Agriculture in India for 1915–16," prepared by the Agricultural Adviser to the Government of India, and is contained in *The Board of Trade Journal*:—Agricultural engineering is destined to play an important part in the agricultural development of India, and when consideration is given to the vast possibilities for the introduction of labour-saving appliances, and for increasing the resources of irrigation from wells—the two most important problems which agricultural engineering attempts to solve in British India—an idea can be obtained of the beneficent results which will follow from its development. In Madras, Bombay, the Punjab, and the United Provinces these problems have been more carefully studied than in other parts of India, and it is in these provinces that considerable progress is being made in developing the existing sources of water supply, and in the introduction of mechanical means of raising water. But for the increased cost of machinery and engineering supplies, and the difficulty of obtaining them, due to war conditions, the expansion of this branch of engineering would have been still greater. In the United Provinces tube-wells have been successful in most parts. During the last two years 30 large tube-wells have been put down in 20 districts. In Bihar a number of successful borings were made, but any great expansion of this work is limited by existing conditions. It is becoming clear that the substitution of mechanical agencies for bullock power is a prime factor in the economic progress of India. This is specially noticed in connection with the sugar industry, the possibility of the extension of which is governed to a considerable degree by the amount of bullock power at the disposal of the cane growers. A considerable advance in the employment of mechanical power in the sugar industry is to be noted in the Bombay Presidency and the United Provinces, and the use of machinery for cane crushing has resulted in a greater yield of cane juice being obtained. In these provinces, as well as in Mysore, various types of power-crushers suitable for use on large estates or (on a co-operative basis) for smaller areas, have been tried, and are being introduced in suitable places. A cane-crushing plant, designed by the Government's sugar engineer, was worked during the year, but further trials are necessary before any definite opinion can be pronounced upon it. It is designed on the smallest scale consistent with commercial utility.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The whole of the market seems to be in an unsettled state. There are two causes, viz., the continued tightness of supplies, with the consequent restriction in the open market sales, and the probabilities attaching to the new scheme of distribution, which remains as unpopular as ever. The full output of the hard coal pits is required to meet the very necessary and large contracts of works, blast-furnaces, and the transport services. Munitions works are trying, but with very little success, to build up substantial reserves for the winter season. They are able to get fair deliveries of the smaller fuels, but the large steam sorts cannot be obtained outside contracts at the full maximum figures. The export trade shows a decline, which has now become a regular feature of this section of the trade, though the exports to allied Powers are still at a very good figure. Neutrals, offering high prices, find it a matter of great difficulty to get supplies. Gas companies are somewhat perturbed at the difficulty in arranging their winter percentages, and find there is a disinclination on the part of the collieries to accept further liabilities. Exactly what will be the outcome remains a matter for conjecture. Briskness prevails in the house-coal section, with householders demanding more than the collieries can supply at the time. This is the result of the desire to lay in winter stocks, and householders are adjured to have a little patience and display some confidence in the collieries and merchants, who are of opinion that the situation will be met in due season. At present the arrears are mounting up on the books. Quotations :—Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley best Silkstone, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire best brights, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire house coal, 17*s.* to 18*s.*; best large nuts, 16*s.* 6*d.* to 17*s.* 6*d.*; small nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; and smalls, 7*s.* 6*d.* to 8*s.* 6*d.* per ton at the pit.

Iron and Steel.—There is no diminution of output. All classes of materials and goods seem to be wanted upon an ever-increasing scale, which tends to make succeeding weeks surpass each other in the bid for the highest record of production. The market for common irons is probably the keenest since the outbreak of the war, and all supplies on offer are sold with the utmost ease at the maximum prices. The bulk of these are for war purposes. Derbyshire brands, which are arriving in better numbers, are being eagerly sought, both in forge and foundry, whilst the sale of basic is not inconsiderable. Lincolnshire brands have not been so large a tonnage for the past few weeks, but are expected to be had more freely when the present important works extensions have been completed. These are of an extensive character and should have a beneficent effect upon output. The pressure for steel for war purposes remains at the high level of the last few weeks. Exports of steel are also being restricted to a figure never before known, and, except for the allied Powers, there seems to be little leaving the country. The greatest concentrations are on the productions for marine work, automobiles and aeroplanes, with special attention being given to the former. It is stated that the task has been allotted to this country of building a record number of ships, and so it has devolved upon the Sheffield shops to exert themselves to the full. From trustworthy circles we hear that the total output to date is quite in keeping with the expectations of the authorities, and if the facts were revealed at some of the annual meetings of the larger corporations they would constitute one of the finest chapters in this country's history of earnest endeavour. Tool makers come under the progressive policy, and the present-day demand for high-speed steel, particularly the higher grade with 18 per cent. tungsten, is very strong. Agricultural engineers, allowed the material they needed, have done exceedingly well, with the limited staffs at their disposal, in providing so much harvest machinery that there will be no fear of a harvest failure for the want of mechanical assistance. The lighter trades are working to the full capacity of their staffs and material, with the cutlery makers finishing important Government contracts. The general state of the overseas trade is still good.

ON BESSEMER STEEL BOILER TUBES.—We read in *The Boiler Maker*, New York, that, as a result of the unprecedented demand for steel and its present scarcity, efforts have been made to provide for the use of boiler tubes made of Bessemer steel, in place of the open-hearth steel tubes as required by the American Society of Mechanical Engineers' Boiler Code. The National Tube Company had requested that wherever possible Bessemer steel tubes be used in place of those made of open-hearth steel, in order to relieve the pressure on the demand for the latter material; the company pointed out that it was nearly two years behind in its orders, and the use of Bessemer steel was suggested as a means of relief. The matter was brought before the Council of the American Society of Mechanical Engineers, with the result that a committee was appointed to confer with the National Tube Company. The committee pointed out the unquestionable advantages of open-hearth steel as compared with Bessemer steel for use in boiler tubes, and urged upon the company the necessity of exerting its greatest effort to cope with the situation. Inasmuch as the company had been instrumental in assisting to develop the present boiler-tube specifications contained in the code, and as these specifications had been found to work out satisfactorily, it was felt that to abandon the requirement of open-hearth steel would be a retrograde movement.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig-iron has been very quiet of late, owing very largely to the suspension of demand for home use, consumers being well covered, and the Scottish holidays, which have closed down requirements of customers north of the Tweed. Now, however, that the Glasgow holidays are over, and the August allocations commence to be made this week, very great activity is confidently anticipated. There is so plentiful a supply of Cleveland foundry iron that producers have been pressing for further orders, so that they are quite in a position to meet heavy requirements. It is gratifying to learn that during the past few days shipments have shown improvement, the tonnage arrivals having been decidedly better. Thus with facilitated exports the continuously heavy demands of our Allies are likely to be more satisfactorily met, and the closing days of July promise to be marked by rather heavy shipments. For home consumption No. 3 Cleveland pig, No. 4 foundry, and No. 4 forge all stand at 92*s.* 6*d.*, and No. 1 is 96*s.* 6*d.*; and for shipment to France and to Italy No. 3 is 102*s.* 6*d.*, No. 4 foundry 101*s.* 6*d.*, No. 4 forge 100*s.* 6*d.*, and No. 1 107*s.* 6*d.*

Hematite Iron.—Little new is ascertainable concerning East Coast hematite iron. Demand is as insistent as ever, both on home and foreign account. Under strict official supervision home consumers continue to receive adequate supplies, and some little surplus is available for sale to customers abroad. Whilst, however, a few home transactions are recorded from time to time, new export business is still very difficult to arrange, not the least obstacle being the still prevailing feeling of uncertainty as to prices in the near future. Against old contracts clearances to our Allies, and particularly Italy, are proceeding fairly satisfactorily, and with the tonnage situation showing signs of improvement shipments may be heavier. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use, and nominally 137*s* 6*d.* and 142*s.* 6*d.* for export to France and to Italy respectively.

Coke.—Values of coke are well maintained, though supply is more than ample. Local demand keeps good, and descriptions needed for the blast-furnaces are still realising fixed maximum rates, average qualities selling at 28*s.* at the furnaces, and low phosphorus sorts at 30*s.* 6*d.* at the furnaces.

Manufactured Iron and Steel.—In the finished iron and steel industries pressure for delivery is unabated, and manufacturers are kept working at high speed to cope with the heavy Government requirements and the large demands of the shipyards. Under the conditions prevailing there is very little surplus material available for sale in the ordinary way of business. Quotations are very firm. To home customers common iron bars are 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; double best bars, 14*l.* 10*s.*; treble best bars, 14*l.* 12*s.* 6*d.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 18*l.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 20*l.* and upward; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel strip, 17*l.*; steel hoops, 17*l.* 10*s.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.*

CORDOBA COPPER AND ELECTRICAL WORKS.—We read in *Revista Minera*, Madrid, that a new company, the Sociedad Española de Construcciones Electromecánicas, has been formed by Peñaroya, Schneider and Co., of Creusot, St-Chamond, Rio Tinto, Banco de Bilbao, Urguijo y Ca., Altos Hornos de Vizcaya and Banca Arnús. These powerful elements show that the company will not lack funds. The nominal capital is 25,000,000 pesetas (1,000,000*l.*), of which half is now going to be issued. The company is to manufacture electrolytic copper and products of this, together with electric material. A site was acquired two months ago between the Córdoba-Sevilla and Córdoba-Málaga railways; the area is about 90 hectares (about 220 acres). Electric current will be supplied by the Peñaroya power stations.

SILICON-COATED IRON.—Since iron containing high percentages of silicon resists the action of acids and bases well, it occurred to W. E. Vawter (*Journal of Industrial and Engineering Chemistry*, June, 1917) to try coating iron with silicon. He prepared first an alloy, approximately $SiMg_2$, by heating powdered silicon with twice its mass of magnesium in a hydrogen atmosphere for two hours at 600 deg. C. Treated with diluted hydrochloric acid the alloy-generated gas, mainly hydrogen containing about 5 per cent. of silicon hydride, SiH_4; he heated the iron (wire mostly) in this gas, expecting that the hydride would be decomposed, and the silicon would settle on the iron. The experiments were successful to a certain extent, when the iron was heated for an hour or more to 550 deg. C., and when oxidation of the iron was prevented. The silicon settled in patches, which were not attacked by salt solution afterwards, though the solution pitted the iron; there was danger, however, of the salt eating its way under the coating. When the iron was first pickled in acid, the silicon adhered better and more uniformly, and such a wire could be kept in salt solution for two weeks, corrosion being confined to the cut end of the wire. Preheating the wire and subsequently heating it to 700 deg. C. proved of no use. But the coating never formed more than a fragile skin on the iron, and so far the experiments do not look of practical importance; yet the method may answer. On copper, aluminium and nickel Vawter could not obtain any silicon deposit.

NOTES FROM THE SOUTH-WEST.

Cardiff.—State control, as far as the South Wales coal trade is concerned, has certainly not proved a success so far. The position at the Cardiff market is most unsatisfactory and disheartening. At no period since the outbreak of the war have there been so many tips idle at the local docks as was the case at the end of last week, and stoppages were reported from practically all parts of the coalfield. Fortunately, particularly on Wednesday, there was an improvement noticeable in the supply of tonnage, and the consequent increased activity of shipping released a considerable number of wagons, with the result that the position at the end of this week will be better. The authorities are taking practically all the available tonnage, and the volume of business is consequently very limited. Moreover, the work of classification seems to be hung up, for the market is still without any information concerning its latest phase. This also applies to the compensation scheme which has been drafted by the Coal Controller. Pitwood is now at about 60*s.*, and there is a possibility of another small reduction in price before long.

Newport.—Almost stagnant conditions prevail in the market for Newport coals. Colliery salesmen are still waiting the direction of the Coal Controller in regard to the points affecting the classification of Monmouthshire coals which were submitted to his consideration. Towards the middle of this week the arrivals of ships more than balanced the sailings, and, consequent upon the release of trucks, fewer pits are now idle.

Miners for the Army.—The new scheme for the combing-out of colliery workers for the Army who are between the ages of 18 and 25 is causing some stir, and when the Joint Coal Board for the Welsh coal trade met at Cardiff, the coalowners suggested the appointment of a joint sub-committee representative of the owners and workmen to carry out the scheme, but the men's leaders were unable to agree to this course, and a special conference of delegates representing the miners of the coalfield is convened to take place on August 2 to consider the whole matter.

"LONDON SHIPPING, 1917."—The 1917 edition of "London Shipping" is now issued. It is published at the price of 1*s.* by *The Journal of Commerce*, 37, Walbrook, E.C. It is a complete directory in a small compass to the shipping and allied trades and institutions in the Port of London. It opens with an index of personal names, this being followed by the various shipping lines, arranged alphabetically, the information concerning the latter covering a short history, the financial situation and the record of the fleets owned. There are also lists of shipbrokers, of the Port of London authorities, &c. The list of officers of the Institution of Naval Architects given in the book is not the latest list. Apart from this the book will prove a handy book of reference in regard to shipping.

THE TRADE OF BRITISH MALAYA.—The steady development of the Malay Peninsula is likely to lead to a greater demand for manufactured goods when business resumes normal conditions. The trade statistics of the Straits Settlements show that the values of imports and exports for the past four years were as follow :—

	Imports.	Exports.
	£	£
1913	388,376	206,760
1914	325,833	188,724
1915	278,449	207,055
1916	376,834	346,580

In considering these statistics, allowance should doubtless be made for the probable increase of prices in 1916, when the preoccupation of Europe in other directions conceivably led to a shortage of supplies. The proportion of exports is large, but it must be remembered that the Straits Settlements ports, besides being distributing centres for the whole of the Malay Archipelago, are the principal avenues of trade for the Federated Malay States, where the prosperity of the tin and rubber industries is leading to other far-reaching developments. The Federated Malay States, for instance, took ironware goods to the value of 361,851*l.* in 1913, of which 118,921*l.* came through the Straits Settlements; in 1914, 383,196*l.*; and in 1915, 172,318*l.* Netherlands India's share of the Straits Settlements exports in 1913 was 38,857*l.*; in 1914, 49,709*l.*; and in 1915 (the last year for which details are available), 87,269*l.* The appended analysis of the sources of supply for three years is interesting :—

	1913	1914.	1915.
	£	£	£
United Kingdom	271,449	241,582	180,157
Belgium	21,568	10,723	—
Germany	20,883	10,556	1,214
Netherlands India ..	17,874	14,936	21,833
Malay States	10,146	12,043	14,692
United States	9,215	8,935	28,334
British India	8,452	8,257	5,962
Austria-Hungary ..	8,129	3,911	—
Hong-Kong	5,867	3,020	4,848
Netherlands	4,992	908	1,497
Siam	3,500	2,452	2,535
Japan	2,615	1,907	1,911

Apart from the elimination of Belgium and Austria-Hungary, the most noticeable feature in the above statistics is the larger import of goods from America.

THE HARLEM RIVER SUBWAY TUNNEL, NEW YORK.

THE ARTHUR McMULLEN AND HOFF COMPANY, CONTRACTORS, NEW YORK.

(For Description, see Page 83.)

Fig. 75. CROSS SECTION THROUGH TUBES.

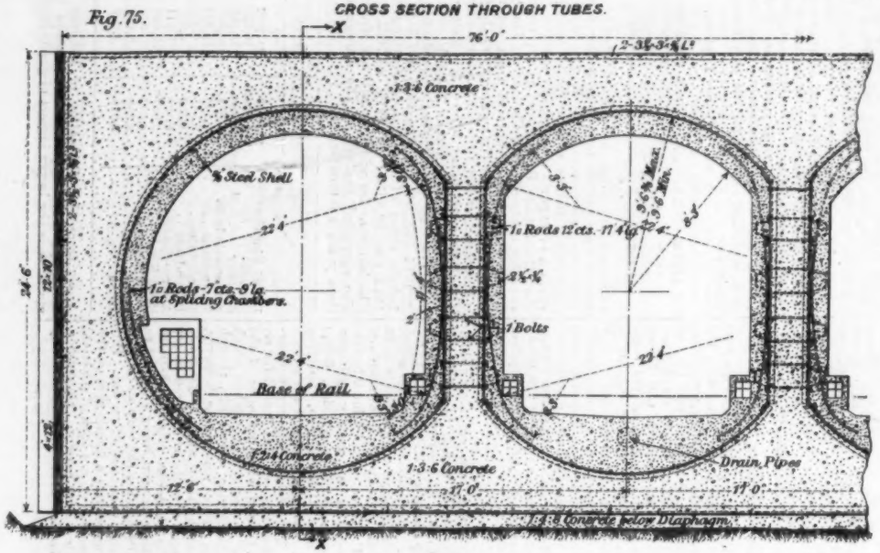


Fig. 76. SECTION X-X

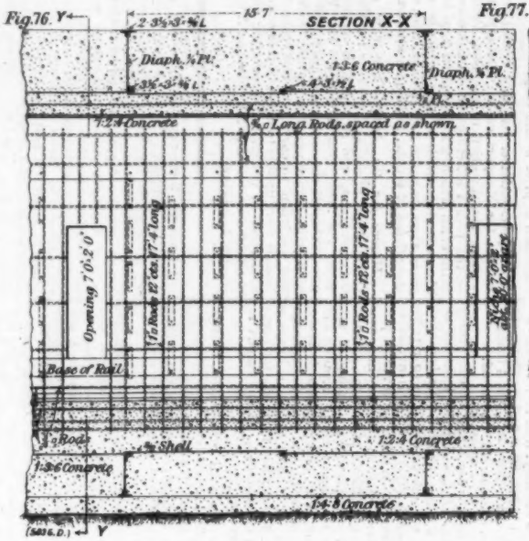


Fig. 77. SECTION THROUGH NICHE.

Fig. 78. SECTION Y-Y

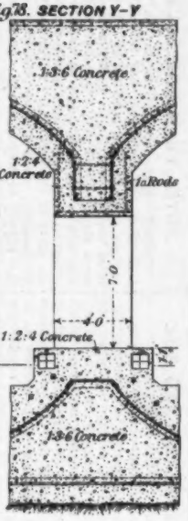


Fig. 80. ELEVATION

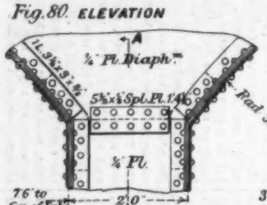
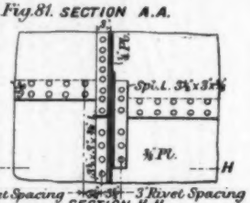
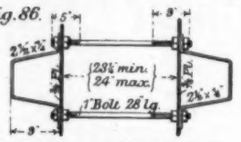


Fig. 81. SECTION A-A



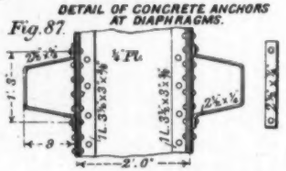
DETAIL OF TIE-RODS BETWEEN TUBES AND CONCRETE ANCHORS.

Fig. 86.



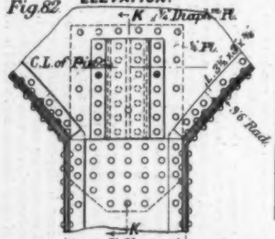
DETAIL OF CONCRETE ANCHORS AT DIAPHRAGMS.

Fig. 87.



CONNECTIONS FOR AIR CYLINDERS ON DIAPHRAGMS D AND D'

Fig. 82. ELEVATION.



SECTION K-K.

Fig. 84.

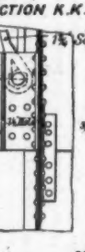
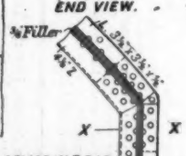


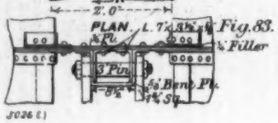
Fig. 85. END VIEW.



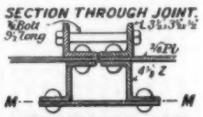
SPLICE IN Z BAR & CONNECTING ANGLE AT ENDS OF TUBES

SECTION X-X

Fig. 83.



SECTION THROUGH JOINT.



DETAIL OF TUBE JOINT. VIEW M.M.

Fig. 88.

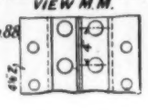


Fig. 89. SECTION A-A

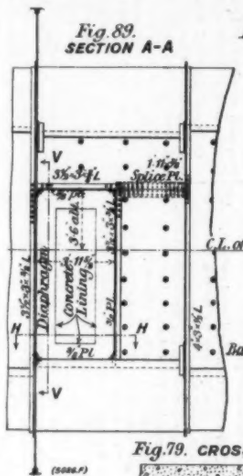


Fig. 90. CROSS SECTION THROUGH OPENING

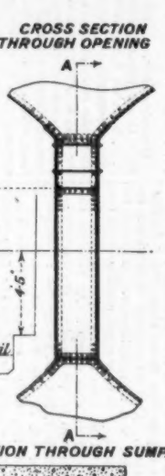


Fig. 91. SECTION V-V

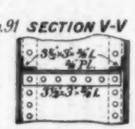
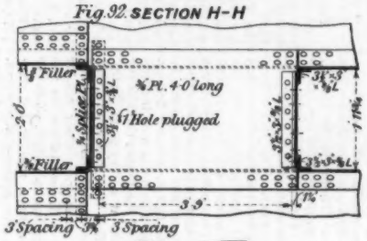


Fig. 92. SECTION H-H



SECTION V-V.

Fig. 93.

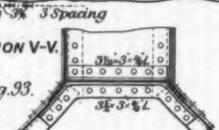
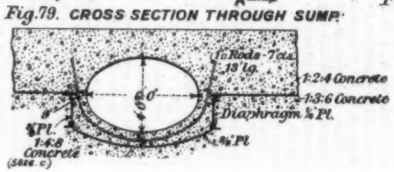


Fig. 79. CROSS SECTION THROUGH SUMP.



THE HARLEM RIVER SUBWAY TUNNEL, NEW YORK.

THE ARTHUR McMULLEN AND HOFF COMPANY, CONTRACTORS, NEW YORK.

(*For Description, see Page* 83.)

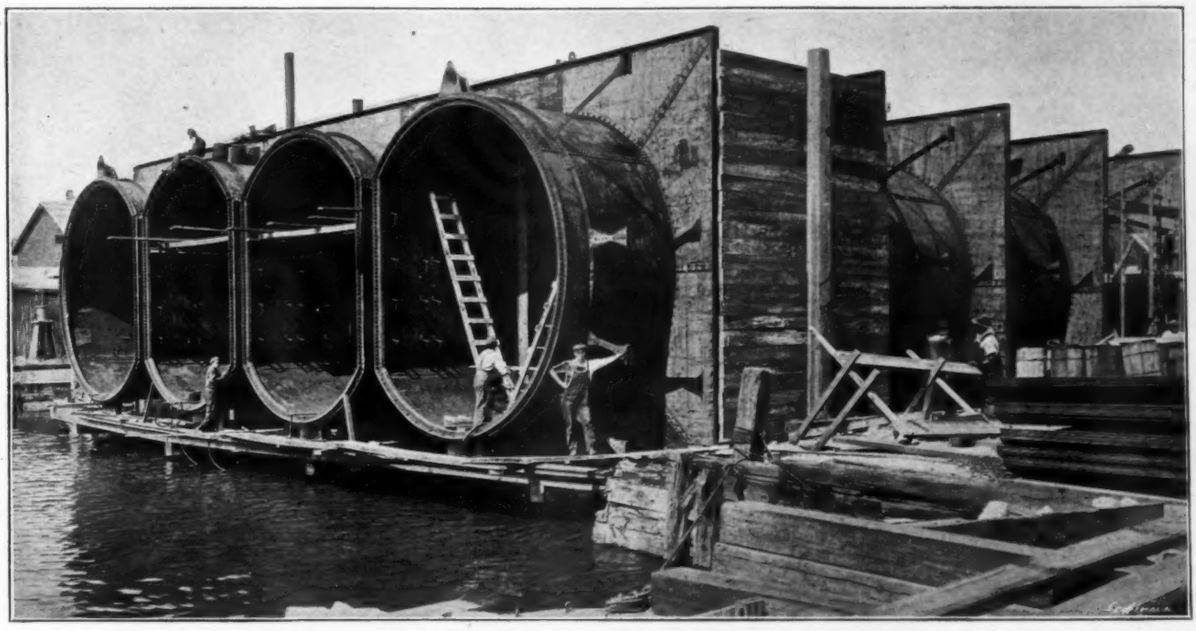


FIG. 38. A SECTION OF THE TUBES BEING FITTED WITH TIMBER BULKHEAD WALLS.

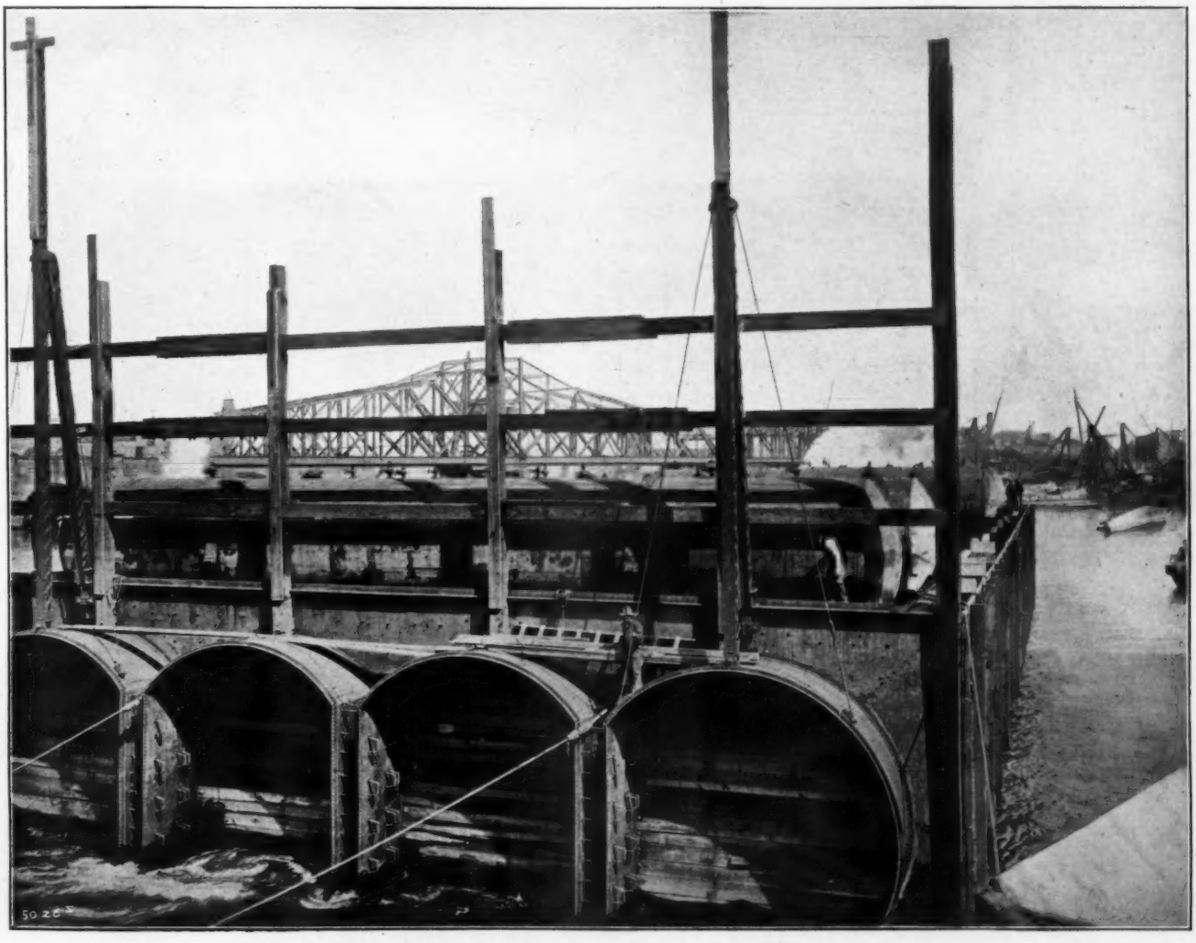


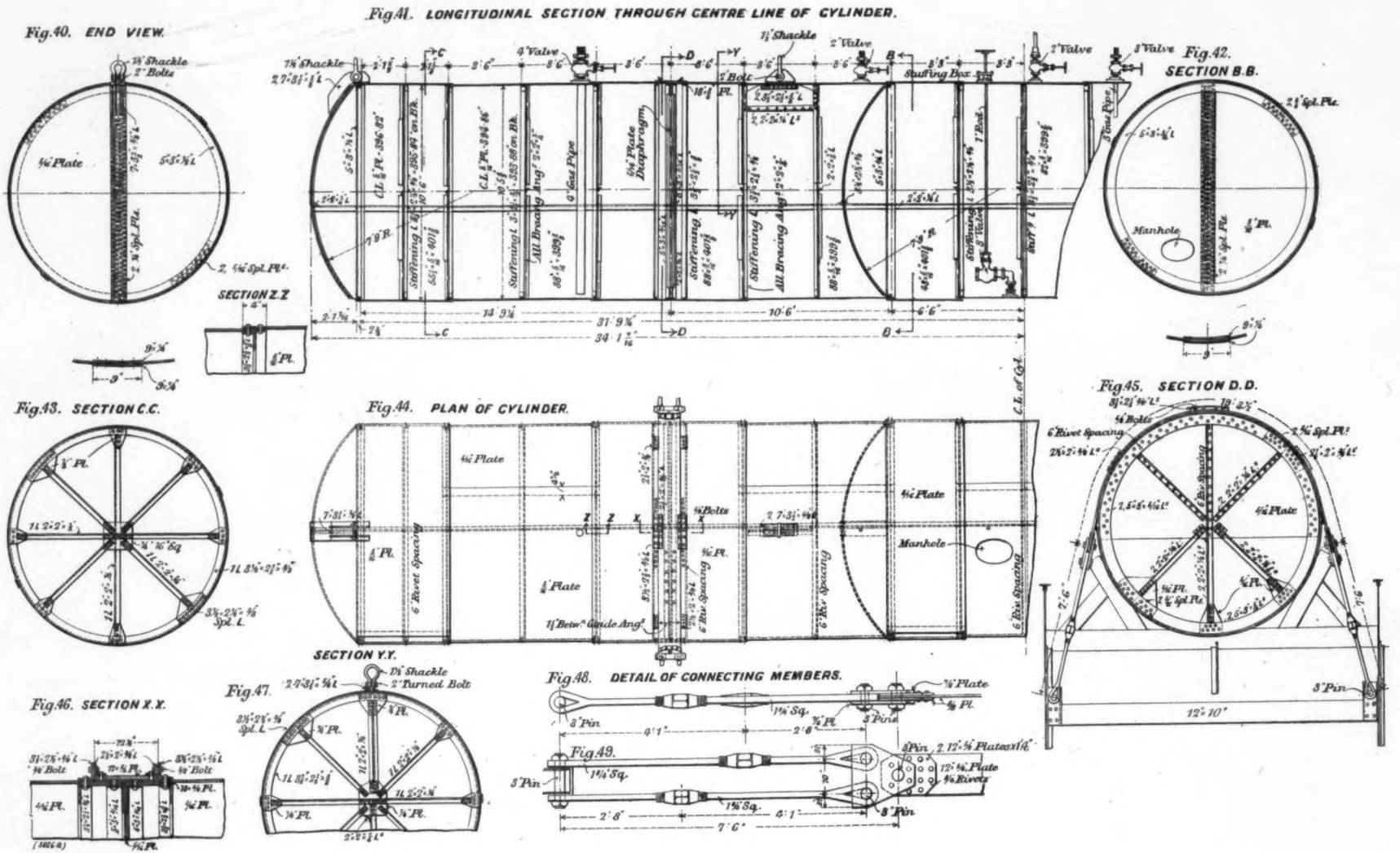
FIG. 39. A SECTION OF THE TUBES FLOATED READY FOR SINKING.

(*To face page* 84.)

THE HARLEM RIVER SUBWAY TUNNEL; DETAILS OF PNEUMATIC CONTROL CYLINDERS.

THE ARTHUR McMULLEN AND HOFF COMPANY, CONTRACTORS, NEW YORK.

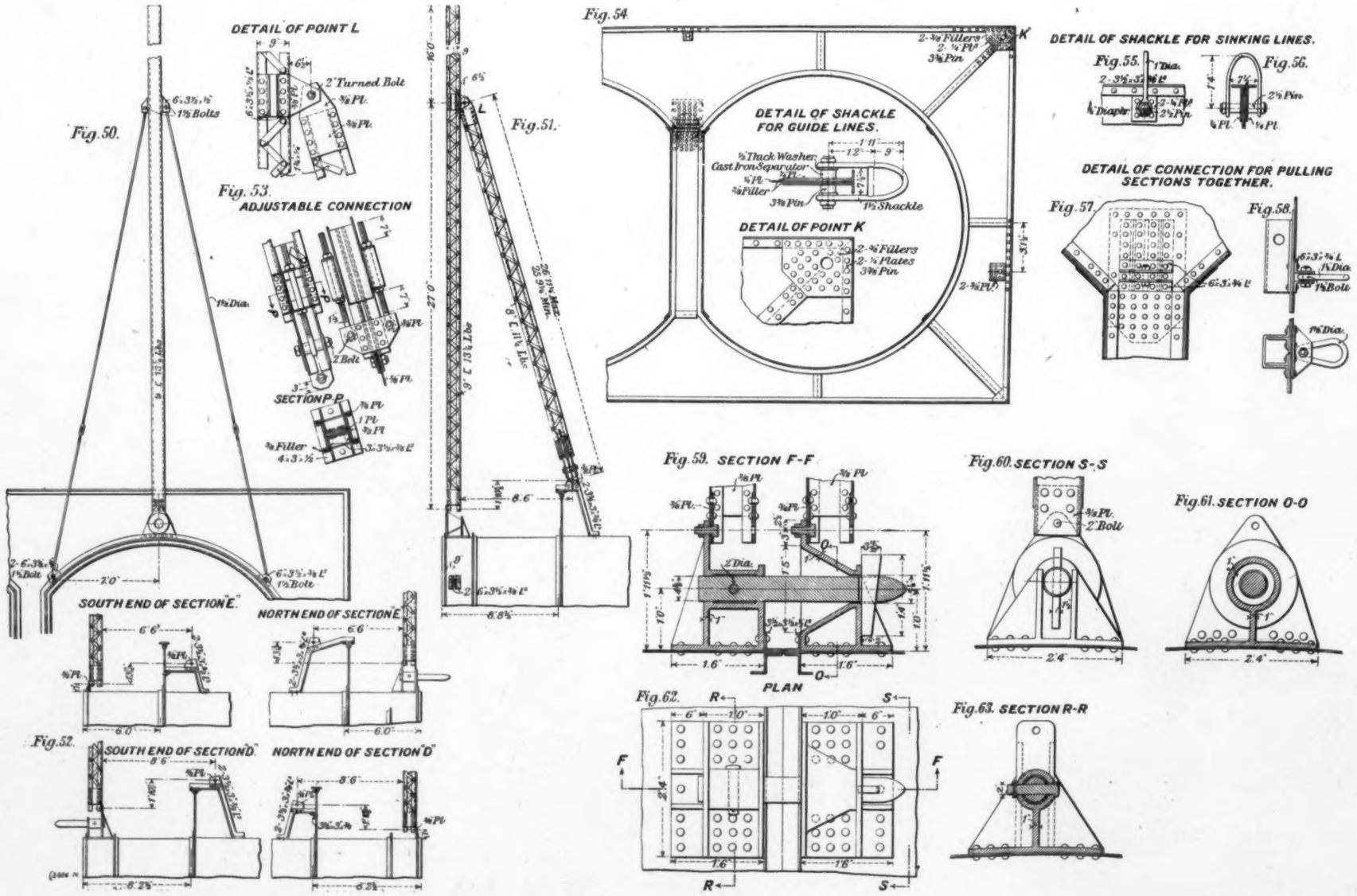
(For Description, see Page 83.)



THE HARLEM RIVER SUBWAY TUNNEL; DETAILS OF SINKING CONTROL GEAR.

THE ARTHUR McMULLEN AND HOFF COMPANY, CONTRACTORS, NEW YORK.

(For Description, see Page 83.)



THE HARLEM RIVER SUBWAY TUNNEL, NEW YORK.

THE ARTHUR McMULLEN AND HOFF COMPANY, CONTRACTORS, NEW YORK.

(*For Description, see Page* 83.)

FIG. 64. A SECTION OF THE TUBES MOORED IN POSITION FOR SINKING.

FIG. 65. FLOATING PLANT FOR CONCRETING STEEL TUBES.

(*To face page* 85.)

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With Four One-Page Plates of the HARLEM RIVER SUBWAY TUNNEL, NEW YORK.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal from 6d. to 8d. per copy. This increase dated from and included the issue of Friday, March 16. The change will not apply to unexpired subscriptions.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, JULY 27, 1917.

INDUSTRIAL UNREST AND MUNITIONS.

ENGINEERS will have read with interest the official summary of the reports of the eight Commissions on Industrial Unrest. Those of them who know the danger of conclusions on important matters formed from anything short of the original documents will sympathise with the official advice to consult the reports themselves, and will act on it as soon as they are issued. In the meantime, and without these documents, most of the recommendations of the Commissioners cannot be discussed usefully or even safely.

But although engineers will be wise to reserve their judgment until they have read the actual reports, a great deal of the subject-matter is of vital concern to engineering manufactures, and may call for more than academic attention from all who are engaged or interested in them. Much of it, doubtless, is political, and therefore not the concern of engineers as such; but side by side with political matters, and sometimes interwoven with them, are others that enter directly into engineering organisation and are an essential part of its work. At the present time, indeed, there should be nothing in Government proposals in the nature of controversial politics. An honourable engagement has been undertaken by the great political parties that such questions shall be suspended during the period of the war; and we should be sorry to have to believe that under cover of present emergencies and in the guise of practical measures for meeting them the Government was intentionally introducing legislation that must settle in accordance with the programme of one group of political parties a variety of highly controversial questions that are of vital importance to the future of industry. Whether a measure for the control of a workshop owes its origin to a political inspiration or not, it is equally a factor in the mechanism of production, to be watched by engineers as carefully as the material on which they work or the tools that they use. The official summary of the present reports, if it does not permit detailed criticism, does at least give ground for the vigilant consideration of engineers when the full proposals are published.

A particularly disquieting feature in the summary is that it adopts implicitly formulæ of the market-place that its authors must know well to be inaccurate and misleading. It refers, for example, to the belief among workmen that the promises of resto ing trade-union restrictions on output and other customs will not be kept; and in referring to the feeling "that pledges are no longer observed as they were in pre-war days," and agreements are treated as "scraps of paper," it has nothing better to remark than that "perhaps sufficient allowance has not been made for the difficulties which have beset all in authority through the ever-changing phases of industrial conditions owing to the war." We will not discuss the extent to which pledges used to be observed before the war, nor recall by whom and on what occasions they were broken; for all parties are at one that, whatever may have been done before this country was purged in the furnace of the war, pledges must be observed for the future, by whomsoever they are given. But the lame and insufficient commentary that we have quoted shows a spirit of conventional insincerity, and is unfit either to inform workers and other parties to industry of the true situation, or to inspire confidence in its authors.

Other instances might be given of the unreality of what the summary presents as the conclusions of the reports; but in itself the multiplicity of subjects that they have covered in the few weeks of their inquiries and deliberations suggests a doubt of their having been addressed to really practical issues. Their recommendations deal with 14 separate subjects, including the admission of labour as a "partner" in the affairs of the community rather than as its servant, the segregation of employers and employed into separate organisations, to joint committees of which should be entrusted the regulation of all industry, the abolition of the freedom of dissentient individual firms from the decisions of such conjoint bodies, and other matters equally comprehensive. These are wide questions, all of the highest interest to engineers in their practical daily work; but it would be hard to imagine any that demand more careful consideration, or are less suitable to be dealt with in a high-speed inquiry made in the gravest possible emergency for the primary purpose of retrieving the existing situation.

From the point of view, indeed, of engineers these reports, so far as the summary conveys their perspective correctly, seem to have lost sight of the real object of the Commissions. We do not underrate the immense importance of the problems with which they deal when we recall the fact that the Commissions had to deal with a problem still more immediate and tremendous. What may be the best basis for the reconstruction of industry is a matter of the utmost consequence for the future; but if there is to be a future for British industry, the present must be so amended and safeguarded that we may now turn all our available resources to their best uses for the needs of the war. And it is deeply to be regretted that the reports show no sign of perceiving the difference in order of magnitude between the causes of unrest and their present consequences. They propose, in effect, that fundamental and permanent changes, hitherto much controverted and in the future likely to be still more so if they are pressed forward in the summary fashion that the reports seem to recommend, should be introduced into industry as the means of meeting the present situation. That would be to use the country's emergency as a lever for introducing changes that were notoriously in dispute. Their introduction under the stress of such coercion would leave ineffaceable resentment and distrust—the very heritage for the future that all parties agree is most sedulously to be avoided. And while it would impose this terrible handicap on the future, it would be wholly insufficient to relieve the needs of the present, and in particular to solve the difficulties that are besetting engineers.

For in substance the real questions for engineers are how many men they can contribute to the service of the nation, by how much they can increase the supply of munitions, and how far they can maintain essential industries, to which workmen in particular will in the future have to look for their living. The Ministry of Munitions has given the most exhaustive and cogent evidence of how this can best be done; evidence that happily is conclusive to the fact that it could be done to an extent apparently proportionate to the national needs. But while on the technical side the Ministry has done its work so well, it has failed to translate its own results into administrative action. Its bureaucratic methods have swamped its engineering material. It has shown that numberless machines and processes can be worked by women as well as by men; yet it still leaves the machines and processes that are to be so worked to be settled from factory to factory, instead of declaring schedules of machines and processes to be worked after prescribed dates exclusively by women unless they are exempted individually on technical grounds. It has control over trades in which to-day myriads of men are doing work that can be done equally by women; yet it allows these men, on the ground that they

belong to these protected trades, to claim an exemption from military service, an exemption to which, when their work can be done by women, they have no more claim than any other men. It has essential industries into which women could be introduced to release really skilled men who are wanted for munitions; yet it or the Government has been spending months in haggling with trade unions as to whether and to what extent and on what conditions this urgent transfer is to be allowed. And all this delay comes nine months after the Government's own Man-Power Board had reported to it that the country was then urgently needing the transfers that are still in question. The vote of the Amalgamated Society of Engineers on the question of enforcing dilution on work which, although private, is indirectly necessary for the conduct of the war, shows clearly the results of the weak policy of the Ministry. Out of a total voting membership of about 200,000, 45,000 opposed dilution and 8000 favoured it, and that, too, notwithstanding other concessions were made on such work.

These are the immediate essentials of the present situation. Two years ago the trade-union leaders, in their appeal to their branches and members, said with truth that even if the fears of workmen that piece-work prices would be reduced by removing restrictions on output, that would be no excuse for maintaining such restrictions in a national emergency such as existed then. What they said of the restrictions on the output of individuals is no less true of the output of whole industries and the nation, and three years of continuous war have made the emergency all the graver. Engineers wish to do their duty, and to do it efficiently. What they look for from the Government is to apply without further parley or delay all our available machinery to dealing with the enemy at our gates. That is their first function and responsibility, and engineers are bound to say expressly that they are not yet discharging it. Second only in importance are the foundations of reconstructed industry; and these will be laid the more truly if a thousand lives a day are not sacrificed while they are being planned.

GERMAN COMPETITION IN SHIPPING.

THE future of British shipping almost means the future of the British Empire, and depends upon two factors: the character of foreign competition and our efforts to meet that competition. For this reason the Bill for the Restoration of the German Mercantile Marine, presented to the Reichstag a few days ago, merits special notice. It is clear that the Germans intend, if possible, to renew their subsidisation policy. It is for us, in conjunction with our Allies, to consider what measures are to be adopted to meet the enemy's designs. German subsidised competition, it must be understood, is not ordinary commercial rivalry, but trade war—organised, bounty-fed, undercutting, deliberately designed to ruin the trade of other countries.

In a statement explanatory of the new Bill emphasis is given to the importance of Germany being able to resume its world-trade and world communications immediately after the war. It is stated that the mercantile marine cannot meet the requirements of the country without financial help from the State. It is observed that German merchant shipping aggregated a gross registered tonnage of more than 5,000,000 tons before the war; that more than 2,000,000 tons have fallen, or are likely to fall into enemy hands; that more than 1,000,000 tons are locked up in the ports of Germany's Allies or of neutral States; and that owing to the rise in prices, new construction undertaken at the risk of owners would not be likely to pay. It is further pointed out that German shipping has been completely paralysed for the period of the war; that shipowners in other countries are making the utmost efforts to increase their tonnage and to invade what have hitherto been German spheres of business; and that in these efforts foreign shipping is in a particularly favourable situation, for the reason that during the war, thus far, it has made great profits, and is consequently in possession of very large reserves. Moreover, foreign shipping is being powerfully supported by the respective Governments. The United States of America and Japan, in particular, have enormously increased their fleets and business.

By the new Bill German shipowners are to be paid direct subsidies, graduated according to the speed at which they can complete their new tonnage. For example, the subsidies may amount to from 60 per cent. to 80 per cent. of the peace value if the ship is put into commission within three years after the conclusion of peace; to from 40 per cent. to 60 per cent. if commissioned between the fourth and sixth years after the end of the war; and to from 20 per cent. to 40 per cent. if the vessel is put in commission between the seventh and the ninth years after the conclusion of peace. Subsidies will also be granted to meet the costs of internment of German ships abroad, and grants will be made to ships' crews who have lost their personal possessions, these grants ranging from a minimum of 12*l.* 10*s.* to a maximum of 175*l.* for captains of passenger ships.

A year ago, the German Government, upon representations from the shipowners, promised to make loans in aid of new construction, up to a total amount of 15,000,000*l.* The shipping companies protested that such loans would not enable them to take the risk of building new ships at war prices. The Government then promised to guarantee the interest on new capital invested by the shipping companies. As a result the larger of of the concerns decided to increase their fleets. The Hamburg-Amerika Line ordered 350,000 tons of new ships, and the Norddeutsche Line 260,000 tons. Many of these vessels are now in an advanced stage of construction. But many of the smaller companies felt themselves in too weak a financial position to make contracts. Now that the United States has come into the war the whole position has been reviewed in the light of this new circumstance, and the above Bill already referred to is the outcome. Thus we see the promise of the most generous—not to say extravagant—State subsidisation scheme ever seriously propounded. If this scheme materialises we and our Allies are in for cut-throat competition. Surely the publication of the terms of this Bill will convince even the most generously disposed of the imperative necessity of adopting combative measures against German commerce as well as against German militarism.

Not less notable than the financial provisions of the new Bill are its clauses prohibiting sale to, or trade with, aliens under certain conditions. Ships constructed or repaired with the aid of subsidies may not be sold to foreigners during a period of ten years after they are put in commission, nor may any chartering or freight contracts affecting such ships be concluded with aliens during ten years without a Government licence. How Germany may manipulate her shipping and shipping laws will depend largely, if not mainly, upon the terms of the coming peace treaty and the other measures we take (or neglect to take) for the preservation of our own shipping interests. It would be more easy to venture a forecast of the broad, general terms of the treaty than to predict how shipping in particular will be affected. There is just a danger that in the larger issues of peace-making the real interests of our shipping may to some extent be neglected. If, after the war, we are to give free and unrestricted scope to German subsidised competition, there is no telling to what extents it may be carried. It may prove not merely detrimental to our welfare, as in the past, but positively ruinous. Germany's aims and methods are clear. Our policy in regard thereto should be equally definite and unmistakable.

It may be recalled, briefly, that in the last thirty years before the war the tonnage of Germany's ocean steam shipping was increased from 500,000 tons, mostly built in Britain, to 5,500,000 tons, almost entirely built in Germany. That great development was not due altogether, or even mainly, to the economical building resources of the country. As already mentioned, it was to a very large extent the outcome of subsidisation. In the early 'eighties the German Government began to give practical assistance to shipping and shipbuilding. Special marine engineering schools and colleges were established. Engineers and workmen were paid secretly to go to England and other countries to learn. Foreign workmen were imported. German bankers were induced to give special encouragement to shipbuilders. In 1884 an Act was passed for the payment of subventions to German-built vessels carrying German goods. In the 'nineties the German trade syndicates began to pay generous export bounties on manufactures, and these have also proved a great aid to the shipping industry. Our shipping has been left unaided to meet the subsidised competition of Germany.

In considering this question of German competition in shipping our supreme interest must be kept clearly in view. A mercantile fleet is as essential as a defensive war fleet to our sea supremacy. It is not merely important that we should retain first place in the international carrying trade—it is imperative that we should keep our long lead of all competitors, especially the Germans. And for this reason: we are more of a manufacturing and less of an agricultural nation, relatively to population, than any other country. Germany employs 40 per cent. of her workers in food production, against our 10 per cent. To balance our huge imports of food and raw material we must export correspondingly large quantities of manufactures. We are bound, therefore, to have an abnormal shipping trade. As our imports always exceed our exports, it is essential that we should build and own the vessels that carry these imports and exports, in order that the earnings of this shipping may help to maintain our trade balance. Again, as our country is small, relatively to population, and far from being self-contained or self-supporting, it follows that we are very much in need of earnings from outside. And, yet again, we have a vast and widely-scattered Colonial Empire. For these reasons we must remain by far the greatest of shipping and shipbuilding nations or drift to ruin. Because we own nearly as much shipping as all other countries put together we must not imagine that our supremacy in this line is unchallengable, or can be retained without effort. Only thirty years ago we made as much iron and steel as all other countries put together; but in the year immediately preceding the war Germany alone produced twice as much as we did. We must beware of Germany beating us in shipping by the same policy as she beat us in iron and steel—namely, subsidisation plus protection and our negligence in guarding our own interests.

MELTING ALUMINIUM CHIPS.

WHEN the price of aluminium had been sufficiently lowered to make the metal available for constructive purposes, a difficulty became pronounced to which thus far little attention had been paid. Aluminium and its rich alloys could not be soldered. It took years before that difficulty was overcome, and meanwhile the use of aluminium was severely hampered. The reason of the difficulty lies in the peculiar character of the affinity of aluminium for oxygen. Aluminium keeps well in air, and does not tarnish, nor visibly oxidise in the cold; on the other hand, when finely powdered and heated, as thermit, it forms one of the most powerful reducing agents known. Though not visibly oxidised in the cold, moreover, aluminium really covers itself with a very fine film of oxide, which protects the metal against corrosion, but which also prevents the metallic coalescence required for soldering and for fusing small pieces of the metal. That property has been utilised in various ways. There is the well-known experiment that an aluminium wire, heated by the electric current, does not really melt because the molten metal is kept imprisoned by the outer skin of oxide. An aluminium wire may also be insulated by being made anode in an electrolytic bath of borax, &c.; Ruder has further utilised this peculiarity in his "calorising" process for iron and steel objects, which are packed in powdered aluminium and alumina and heated to 950 deg. C. But the peculiarity leads to waste when scrap or powdered aluminium is to be remelted for renewed use. Fortunately the waste is not so serious as in the case of brass, when zinc is volatilised. From an investigation published by Messrs. H. W. Gillett and G. M. James, in Bulletin 108 of the United States Bureau of Mines, we see in fact that the waste of aluminium due to oxidation did not appear to

amount to much more than 200,000 dols. in 1914, in the United States. Even if that figure had been doubled or trebled since it would not constitute grave waste, considering the enormous demand for aluminium in the automobile, cooking and miscellaneous other industries and the late rises in prices.

The waste is not large, because clippings and punchings which are kept fairly clean, as well as old castings and chips, do not give much trouble; pressed or cabbaged into bundles they yield a good ingot metal; scrap wire and cables are made of fairly pure metal, and they do not cause waste either, as long as they are not covered with insulators. But the chips and borings from engine beds, crank and gear cases, bodies, steering wheels, hub caps, fittings, &c., into which probably 95 per cent. of all aluminium castings go, are dirty with oil or soap emulsion and dust and grease, and the grease and dirt give the trouble. The oil and emulsion seem to soak into the metal, promote oxidation, and make the pieces stick together; the dust and other metals of the floor get mixed up with the turnings, which are very curly, moreover, so that magnetic separators have a hard task in dealing with the greasy turnings. Some of the small dealers, it is said, cannot resist the temptation of adding road dust and foundry sweepings to the borings. For these reasons the largest American refiners probably do not average more than 65 per cent. recovery from the ordinary dust-laden borings. The Bulletin mentions that one firm, confining itself to the recovery of aluminium borings, did not live more than a few months, whilst another runs that department intermittently only, when the prices are favourable, although nearly 25,000,000 lb. of aluminium castings were used in the year ended July, 1915. As a rule large pieces are picked out from the scrap; the other pieces are tumbled, dry or wet, in barrels, dried, and then melted; the scum of oxide, dirt and metal is remelted, with the addition of fluxes, and the dross from this is sold, or subjected to wet tumbling or thrown away.

Before turning to the actual processes used and to the experiments of Gillett and James, we ought to say a word about aluminium nitride and carbide. It has been suggested that liquid aluminium absorbs nitrogen from the atmosphere. The nitrogen-fixation process of Serpek rests on the absorption of nitrogen by mixtures of alumina and carbon, and the dross floating on the molten aluminium certainly contains some nitrogen. That aluminium also takes up carbon from graphite crucibles has been concluded from the odour of fresh fractures of the metal, an odour suggestive of acetylene. But aluminium carbide Al_4C_3 yields methane (and not acetylene) when treated with water, and the smell is probably due to carbides of other metals present. On the other hand the recent experiments of H. S. Bennett confirm Fichter's statement that, contrary to other observations, liquid massive aluminium does not absorb nitrogen when this gas is forced through the metal; Carpenter and Edwards did not find more than 0.0055 per cent. of nitrogen in molten Al either.

Commercially the chips are remelted, sometimes with addition of a flux. According to R. Seligmann the British practice does not favour the use of fluxes, and he himself would not recommend chlorides of ammonium or zinc (the latter would contaminate the Al); but he had obtained good results with low-melting fluorides (of calcium and potassium, with alkali chlorides), even for dealing with powdered aluminium; the fluoride fluxes dissolve the aluminium oxide, and are hence used for soldering too, but they attack the crucibles. In America the scrap (cleaned to a certain extent and dried) is melted down in crucibles, pit-furnaces or iron pots (oil or coke-fired), the paste poked down with a stirrer, and sal ammoniac added from time to time; the dross is apt to catch fire, and would melt a hole through an iron plate on which it is spread in a layer of a few inches. In one works the borings were passed through a magnetic separator and were mixed with considerable proportions of salt and fluorspar; zinc chloride and salt are the flux in other works. The experiments of Gillett and James were made on a laboratory scale with samples of 1 kg. or 2 kg.; particulars are given of a large number of experiments, some specially conducted in accordance with suggestions made by manufacturers. The chief conclusions were the following:—Feeding the chips into the molten electrolytic bath for reducing pure aluminium was found decidedly inadvisable in the case of dirty chips, as it would foul the metal, and be of doubtful value in general; but that would be a question for the respective works, which keep particulars of their processes to themselves. Briquetting the scrap would require rather expensive machinery, and would pay only in large refineries commanding ample material and using the machinery for other purposes as well. The use of special (electric, vacuum, retorting) furnaces, which prevent access of air without promoting coalescence by stirring, did not look promising. The often-advocated method of pushing the borings beneath a heel of molten metal seemed advantageous in so far only as it approached a puddling process. The latter process proved useful for clean borings when the temperature could be kept low, practically at melting-point, to prevent oxidation; but it involves constant manual labour and is not thought suitable for large units and dirty scrap. Some mechanically stirred furnace, analogous to the Côte-Pierron or Montefiore furnaces for melting blue powder (zinc), might answer. The use of volatile fluxes (chloride of zinc and ammonium) would be advantageous at the end of the puddling, not for the actual melting. Other fluxes, acting as covers excluding the air and promoting coalescence, would be required in considerable percentages, and should be of low melting-points; 20 per cent. or 30 per cent. (of the metal weight) of a mixture of 85 per cent. of common salt and 15 per cent. fluorspar answered best; the flux should be mixed with the chips before charging. The advantage would, with clean borings, probably be limited to labour-saving, as little stirring would be required; for pit fires the flux method seemed to be preferable, for iron-pot furnaces the puddling process.

Washing processes seem to deserve more attention in practice than they have received. Cold water will not remove grease from borings, of course, nor did hot water; but the experiments are hardly conclusive on that point. Washing with gasoline proved very expensive; washing with dilute caustic followed by centrifuging answered. As regards the metal yields realised in the various processes, they came up to 87.5 per cent. with clean and dirty chips. Finally, the quality of the ingot from chip aluminium has to be mentioned. For small castings additions of, say, 10 per cent. of boring ingot to the new metal seem unobjectionable. With respect to large castings some foundrymen assert that 30 per cent. of boring ingot markedly decreases the risk of cracking, whilst others are decidedly of the opposite opinion. Many factors have to be considered in this connection; the melting of the metal in an oxidising atmosphere may be more dangerous than impurities. On the other hand babbitt and white metal, bronze and brass chips may have been mixed with the scrap aluminium. Copper will not do harm. As to zinc and the desirable and permissible percentage of zinc, European and American opinions differ. Lead is undesirable, tin less harmful, antimony doubtful; up to 0.2 per cent. of manganese and more probably may be useful, and 1 per cent. or 1.5 per cent. of iron is not objected to; silicon is not desired. In whatever way the aluminium scrap is to be oxidised, it is well to keep it as clean as possible.

NOTES.

HAMMERING, PRESSING AND ROLLING STEEL.

IN a paper by Mr. John L. Cox, of the Midvale Steel Company, read before the American Iron and Steel Institute, New York, on May 25, a comparison is made between the action upon steel of the hammer, the press and the rolling-mill. In this the author says it is generally understood that a forging press costs about as much as an equivalent hammer with its foundations. A well-designed press uses probably under one-third of the steam consumed by the hammer. In most cases the output from a hammer is less than from a press, but when used for cogging down ingots for subsequent rolling, the press cannot compete with the hammer, even though it be equipped with power-handling devices. Thus, under a 10-ton double-acting hammer, cogging 14-in. square ingots to 5½ in. square, corners broken, cut in lengths, an average eight-hour output was 30 ingots, on occasions 34; whilst the average output of a 1,200-ton steam hydraulic press was 22 ingots, occasionally 27. When obtained under a hammer of ample power, forgings show test results practically identical with those of pressed forgings made under the same conditions; but the danger in solid hammered work is always that for the sake of economy too light a hammer will be used and the forging left with an imperfectly reduced grain size towards the centre. In spite of all its excellences and its adaptability to a wider variety of work, the press has two failings, both due to its lack of impact; first, it is harder to get rid of scale, and, in the second place, it cannot strike in a mould as large a forging as a hammer its equivalent in other respects. In the author's experience a 500-ton press is the equivalent of a 2¼-ton hammer, a 1,200-ton press the equivalent of a 10-ton hammer, a 2,500-ton press the equivalent of a 25-ton hammer; yet a 4½-ton hammer can make drop-forgings which are beyond the power of a 1,200-ton press, and a 2¼-ton hammer can about equal it. In both the hammer and the press the action of the pressure is normal to the face of the die and the pressure equal at all points on flat die faces. In the rolling-mill compression is most rapid, and therefore the pressure greatest, at the line of intersection between the faces of the rolls and the surface of the unreduced portion of the piece going through them. There is also a much narrower limit in reduction. The tendency of rolling is to have a more superficial action than either hammering or pressing. The operation of rolling is far more rapid than either pressing or hammering, with a consequent high finishing temperature. If a heavy mill were to roll from ingots at a low initial rolling temperature and finish at the same temperature as material treated under a press or a hammer, the author believes the difference between rolled and forged products would largely disappear. Hot rolling tends to prevent the development of surface defects, but hot rolled material will not give good results on physical tests; hence it is common for rolling-mills to refuse orders for billets to show definite physical properties and to insist upon a chemical test only, whereas forged billets are frequently tested physically. Owing both to the rapid cooling of thin plates and to the excessive pressures required for their production, it is found that about 5 in. is the limit to the thinness of forged plates.

CONCRETE ROADS.

Whilst concrete foundations for the pavements of heavily-travelled streets have long been widely adopted in this country, very little use has been made here of concrete roads of the type of which some 50,000,000 sq. yards are now in service in the United States, and appear to have yielded results satisfactory to those responsible for their construction, as is shown by the steadily increasing mileage. In view of the generally accepted view that circumstances will in the near future necessitate extensive highway improvements in this country, the merits and demerits of the concrete road are well worth an inquiry. The Roads Improvement Association (Incorporated) commissioned accordingly Mr. H. P. Boulnois, M.Inst.C.E., to prepare a report on this type of road construction, which has now been issued in pamphlet form, and will be studied with the care it deserves by all interested in the further development of highway traffic. The report quotes the conclusions of a number of prominent American highway engineers that concrete roadways have a low total annual cost, are well suited to both horse and motor traffic in all weathers and in all seasons of the year, and that they are comparatively noiseless. Mr. Boulnois reports that even at Sioux City, Iowa, where the annual temperature range is from 35 deg. below zero Fahrenheit up to 115 deg., and where there are frequent terrific rainstorms, the concrete pavements have proved satisfactory throughout an experience now covering a period of six years. The roads here are 6 in. thick and are not reinforced; 1 : 3 : 5 concrete being employed. Some of the roads have a gradient of 1 in 9. American engineers

report that where cracking occurs it is due to the unequal settlement of a poor subgrade. If an old roadbed is to be used it must, they state, be scarified, reshaped and rerolled for the entire width of the pavement, and it must be kept dry by suitable drains. Where the ground is bad the concrete should be reinforced, but this expense is unnecessary in gravelly or sandy soils where the drainage is good. Mr. Boulnois is able in his report to quote some examples of concrete roads in Great Britain. The type has been used at Leith for 30 years past, but owing to insufficiently rigid specifications has not proved wholly successful. About three years ago a concrete road was constructed near Swindon for military purposes and has proved satisfactory. In this case the concrete had a thickness of 6 in. and was laid on a bed of cinders 3 in. thick. At Chester, Mr. Matthews, the city engineer, has adopted concrete for the roadway of several streets. These have proved satisfactory, but the traffic is not very heavy, being equivalent to only about 3,000 tons per yard width per annum. A similar step has been taken in Dunfermline, but here, again, the traffic intensity is moderate. An interesting experiment was made near Gravesend in the autumn of 1914, by adopting concrete for the surface of a road carrying about 1,000 tons a day, mainly made up of motor omnibuses and high-speed commercial motors. This did not prove a success, largely because of faults in the specification and owing to the prevalence of bad weather during the construction period. Mr. Boulnois reports, however, that some portions constructed under better conditions have stood well, and that the experiment has been of great value in showing the faults to be avoided. The report concludes with a suggested specification, based upon the data acquired in the course of the investigations. Copies of the report (price 7*d.* post free) can be obtained on application to the Acting Secretary, Roads Improvement Association, 15, Dartmouth-street, S.W. 1.

RAPID SHIP-REPAIRING.—Last September, says the *Rassegna dei Lavori Pubblici*, Rome, a fire broke out in the steamer Milazzo whilst she was at sea, the fire destroying the aft portion of the ship over about 90 yards and endangering her. The repairing work was entrusted to the Fiat San Giorgio Company, who completed it in about two months less than the six months stipulated.

ELECTRIC STEEL IN THE UNITED STATES.—According to *The Iron Age*, the United States Government is expected to manufacture electric steel for both projectiles and steel castings at the earliest opportunity in various parts of the United States. Contracts will probably be signed soon for six 6-ton Héroult electric furnaces. Three of these, it is understood, will be installed at the new Government projectile plant at Charleston W.Va., while the other three will produce steel castings, one at the Washington Navy Yard, one at Puget Sound and one in the Boston district.

BRITISH CARGO STEAMSHIP SERVICES AND FORWARDING AGENCIES.—The Department of Commercial Intelligence is prepared, on application, to furnish available information regarding British cargo steamship services trading between the United Kingdom and all ports of the world. Applicants for information are requested to state their requirements clearly, particularly indicating the ports or districts between which cargo is to be carried. Information regarding British forwarding agencies from the United Kingdom to all parts of the world may also be obtained on application to the same department. Firms requiring information are requested to give full details, especially in regard to the ports or districts between which goods are to be carried.

MESSRS. J. SAMUEL WHITE AND CO.—The board of this company has been augmented by the appointment as deputy chairman of Sir James B. Marshall, K.C.B., who recently relinquished the important position of Director of His Majesty's Dockyards at home and abroad. Sir James entered the Royal Dockyard at Portsmouth in 1867, after being educated at the Royal School of Naval Architecture and the Royal Naval College at Greenwich. He has since been engaged in successive positions of increasing responsibility, culminating appropriately in his appointment as Director of Dockyards in 1906. A naval architect of great experience and organising ability, he maintained the dockyards at a high degree of efficiency, and the immense amount of refit and repair work done during the war proved invaluable in ensuring that the fighting power of the Fleet was always at its maximum. According to Admiralty regulations he was due to retire last year, but at the request of the First Lord continued in office some months longer. He was made a C.B. in 1902 and K.C.B. in 1911.

LITERATURE.

(1) *Modern Gasworks Practice.* By ALWYNE MEADE, Assoc.M.Inst.C.E., Lecturer in Gas Engineering and Allied Subjects to the London County Council, &c. With an Introductory Note by STANLEY H. JONES, M.Inst.C.E. London: John Allan and Co., *The Gas World* Offices. [Price 18*s.* net.]

(2) *Operation of Gas Works.* By WALTER M. RUSSELL, Manager Emporia Gas Company, Member American Gas Institute. New York: McGraw-Hill Book Company; London: Hill Publishing Company. [Price 8*s.* 4*d.* net.]

THE general advances made in recent years in all branches of industry have not been without influence on gas manufacture, and the wider application of the product to commercial, domestic and public purposes has necessitated the introduction of improved, but often complicated, processes which combine in their result the art of the chemist and the skill of the engineer. It is no easy task to explain the mechanical equipment of a modern gas works, and the chemical reactions effected by the processes adopted. Mr. Meade, possessed of the necessary training and experience to make him a competent guide through the many intricacies encountered, has fairly met these difficulties, and likewise those imposed by a wide and scattered literature and the pursuit of very varied methods in actual practice. He has not only acquitted himself well on the scientific side, but has given his book an additional value by discussing some of the problems connected with the laying out of gas works, extensions, and cost of substitutions of mechanical for manual labour. Nor does he forget the statutory requirements with which a watchful legislature has saddled the problem of gas manufacture. Much ground is covered in various directions: many interests are served and an acknowledged want remedied.

The main principles controlling the manufacture of gas are simple; they have been practised for more than a century, but the details are continually varying according to the requirements of industry, the rise and fall in the value of by-products, and to some extent the accessibility of raw materials. It is curious to note, as the history of progress is unfolded, how frequently the crude suggestions of some old-time gas engineer, that failed to find general approval in his own day, have been resuscitated and hailed with acclamation under changed and more pressing conditions. Innovations, sound in principle and economical in working, recommended themselves to skilful engineers on their merits, but could not find general adoption till the advent of larger works made more evident the imperfections they were intended to remedy. The tar tower may be quoted as a familiar instance of revival, that after having fallen into discredit has come to be regarded as a most satisfactory means for seal regulation and tar and liquor disposal. Exhausting machinery, a necessary adjunct in large works where porous substances have superseded cast-iron in the construction of retorts, and introduced as far back as 1839, is another instance of modern necessity recognising the long-despised merits of a neglected apparatus. The conversion of cyanogen into ammonia was practised 70 years ago, and has now been revived owing to the difficulty of finding a market for hydrocyanic acid. The composition of water gas was known to Lavoisier at the end of the 18th century, and its production was effected on a commercial scale long before its value as an enriching agent was perceived and its many good qualities acknowledged. It would be easy to quote other instances in which the inchoate, undeveloped practices of one generation have formed valuable additions to the equipment of another.

The changing times are also shown by the greater care for health and increased attention to the conditions under which the work is carried on. This welcome tendency is illustrated by Mr. Meade in weighing the relative advantages of the stage-house and the subway-house; that is to say, in designing the retort-house, is it desirable that the clinkering floor should be on the ground-level and the charging floor above, or the charging floor on the level, with excavations below ground for producers, slides, &c. Obviously the subway-house offers some advantages for the intake of coal, and it is stated that the capital expenditure on the stage-house will be from 2*l.* to 6*l.* higher per mouthpiece. Nevertheless, the stage-house is recommended, mainly on the ground that the heat in the subways, coupled with insufficient ventilation, is deleterious for the workpeople, while the steam arising from the crushed coke or clinker is injurious.

We are on more technical but more controversial ground in attempting to decide on the adoption of horizontal or vertical retorts. The difficulty of decision arises from the equally poised balance of the relative merits of the two systems. In old-established but smaller works the horizontal bench has asserted itself on the score of convenience, if not of economy, while the vertical form is claimed as the more suitable for carbonisation in bulk. The vertical retort may be said to be still on its trial, and though figures are given which point to a successful working of the continuous vertical system, these have to be received with caution, since comparisons over long periods are wanting. In the following table, contrasting the fuel consumed under the various systems, and therefore only one factor in an involved problem, the percentage is reckoned on the pounds of fuel used per 100 lb. of coal carbonised.

Class of Retort.	System of Firing and Type.	Percentage of Original Weight of Coal.
Horizontal	Direct-fired furnace	28
,,	Generator furnace...	15 to 18
,,	Regenerator furnace	11 to 14
Vertical	Intermittent type...	16
,,	Continuous type ...	11½
,,	Outside producers..,	13 to 16

The slight advantage apparently in favour of the continuous type of the vertical retort is hardly conclusive, and those best informed will have little difficulty in subscribing to the verdict of an anonymous authority, who had ample opportunity of experimenting with all kinds of plant. "His opinion is that, on summing up the respective balance sheets, very little difference can be found between the two competitive systems, and local circumstances may settle the question one way or the other."

When advantages are nicely balanced there are two conditions which may turn the scale, the possibility of reducing labour and the value of the by-products. The vertical retort, continuously fed, lending itself admirably to manufacture on a large scale, is in a favourable position to employ labour-saving plant to advantage. Mr. Meade states that 20 years ago it was necessary to employ 20 men to produce 1,000,000 cub. ft. of gas per diem; to-day, where large installations of vertical retorts are available, the number is only four. When examined, the saving effected by this reduction of labour is not so considerable as it appears. The saving of the wages of a workman may warrant the outlay of 500*l.* or 600*l.* on machinery, and in a particular works 7,250*l.* were expended in elevators, conveyors, coal breakers, charging machinery, and coke-handling plant. Allowing for interest, maintenance and depreciation—a total of 16 per cent.—the annual charge will be 1,160*l.*, equivalent to the wages of 13 or 14 operatives, and if the management can dispense with the services of 16, as stated, the advantage is on the side of the works. Such a small margin can, however, easily disappear, but where gas is made on the scale of 1,800,000 cub. ft. per diem, the author thinks an economy could be effected. But the improvement is rendered possible not by the mechanical handling, but by the large scale on which the operations are conducted.

The second point, the character and the amount of the by-products, appeal to us at the present time, when the employment of coal-tar products in the manufacture of high explosives by nitration is pressingly needed. Benzol recovery is now a matter of national importance, since toluene, which forms 10 per cent. to 25 per cent. of the benzol, is indispensable in the manufacture of trinitrotoluene. Where gas has been produced by carbonisation at moderately low temperatures, it might be possible to remove one-third of the benzol content of the gas without reducing the calorific value below the standard of 500 British thermal units per cubic foot, or to recover 1 gallon of benzol per ton of coal. In vertical retorts with regenerating furnaces the aromatic hydrocarbons are not conserved to the

same extent. On the other hand, with a lower temperature the yield of gas would be decreased to probably 10,000 cub. ft. per ton, but the higher calorific value would permit the volume to be made up by the addition of blue water gas. But with the possibility of producing nearly 16,000 cub. ft. of gas per ton, with a calorific power of 530 British thermal units—a feat that is said to have been achieved with a ton of Durham coal—the remunerative value of the gas yield is not seriously threatened. The point is one of some importance, and the author might have discussed it more fully in his chapter on the carbonisation of coal, one of the best in the book.

To many fascinating topics raised by Mr. Meade it is impossible to refer. We should have much liked to follow him in his discussion of refractory materials, the purification of gas, the recovery of cyanogen, and particularly the manufacture and use of water gas. All these and many others are adequately treated, and the book is likely to hold its own as a valuable work of reference concerning the technique of gas manufacture. Having referred, however cursorily, to the successful treatment of financial and chemical problems, we will not conclude without directing attention to the third capacity in which the author figures, that of the engineer. By way of example may be selected that familiar apparatus, the gasholder, which by reason of its assertiveness obtains from the public a greater measure of consideration than its importance warrants. Mr. Meade hints at the possibility of its disappearance in a distant future. We would we could share this hopefulness. The object of the "gasometer" is to hold in reserve a sufficiency of gas to meet the unknown fluctuations in demand. In recent years the hourly consumption has become more regular, and when the load curve is completely levelled out the necessity for the gasholder will disappear. But opposed to this welcome suggestion—welcome because storage requirements make great inroads both on initial capital outlay and the ground area required—stands the incontestable fact that whenever a new holder is erected on a works, its content is invariably greater than its predecessors. Consequently we have gasholders with a capacity of 12,000,000 cub. ft. and with diameters of 250 ft. and more. Evidently in the construction of such huge buildings, little more than shells, many problems arise, not the least important of which is protection against wind pressure, to which the author devotes a careful, if not exhaustive, analysis. A great simplification is indicated by a form erected at Nuremberg, in which the roof is the only moving portion, sliding by means of guide rollers within the tank. Such a form does away with the complication of "lifts," and apparently would permit of strong buttressing from the outside. The expensive water tank that provides an elastic gas-tight seal is dispensed with, though a water seal has to be provided. This seems to be a weak point, necessitating constant pumping, and in severe winters might give some trouble from frost. The external appearance should be as severely simple as the spiral-guided holder, and the abolition of the braced guide-framing is a favourable feature. In the ordinary form the stresses in the struts and ties furnish some interesting problems, and if the structure is of steel, temperature effects add to the complication. All these points are well handled by the author, but may be a little foreign to the purpose of the book. Certainly they add to the interest, and it would be ungracious to object to this slight excursion into the domain of pure engineering.

(2) Mr. Russell's book, though dealing with the operation of gas works, is of quite a different character to the preceding. The author presumably imagines his reader in charge of a gas plant of moderate size, and that he wants to get the best results from the machinery provided. Consequently no detailed description of construction or discussion of the merits of competitive designs is given, and it is a little difficult to see how a manager, from the limited information supplied, is to increase and widen his knowledge of the principles and practice of gas-making, one of the objects of the manual. There are many useful hints on management, drawn from the author's experience, and if these are turned to account they give the book a certain value.

In the first chapter we have notes on organisation and discipline given with American terseness and directness of aim, which are salutary and sometimes amusing. "It is a splendid thing," we are told, "where the men admire a boss and regard him with affection as well as respect, but the affection is not essential to success, and the respect is . . . never parley or argue with a man for a minute. If he has an excuse, listen to it, but don't argue."

The second chapter is devoted to the subject of chemical controls, the taking of samples for various purposes and the simpler forms of analysis. It is difficult to think that a responsible post would be filled by anyone who was not familiar with much that is very clearly stated in this chapter. It illustrates, however, the relative importance that experienced managers attach to necessary operations. For instance, the method described for the management of the secondary air to the benches, with the view of maintaining a satisfactory supply of oxygen with an economical consumption of fuel, appears inconveniently elaborate and long in application. The author does not state explicitly the degree of efficiency attained, or what percentage of the fuel used is effective, so that one cannot compare the efficiency with that reached in this country, or trace in what form the original heat units are recovered. The diagrams of coal sampling are very amusing, and apparently the work is carried out very thoroughly, far more than it is here, for the choice of coal is generally restricted by the proximity to coalfields and the facilities for carriage. It would, therefore, have been of interest to have followed the coal through its course in the process of gas-making. For detecting ammonia, sulphur, sulphuretted hydrogen and naphthalene, methods of sampling and of interpreting the results are given, but we are left in doubt as to the degree of purification insisted upon by custom or American law. To attribute the presence of naphthalene in water gas to the employment of too high a temperature is probably correct, but we doubt if the same explanation is applicable to coal gas.

In the chapter on coal gas the author quotes some general instructions from two recognised authorities which are eminently practical, if occasionally bordering on the obvious, and the chapter on water gas is interesting by exhibiting some points in which the manufacture in America differs from that followed here. There is no reference to the employment of processes in which oxygen is admitted along with the steam to the base of the generator, resulting in the production of a gas practically free from nitrogen, but containing about 70 per cent. of carbon monoxide, from which it may be concluded that the method has not found favour in America. The importance of dry steam is insisted upon, but as no mention is made of superheating the steam before admission to the generator, probably the questionable advantage of the method receives little support from practice in the States. The quantity of air admitted during the "blow" appears to be less than with us. The quantity of 1,400 cub. ft. of air per minute per 1,000 cub. ft. of gas is mentioned as suitable for the blast, or 40 per cent. less than is usual in this country. This chapter, together with the following, on the care and management of plant generally, is very satisfactory, considering the space allotted to each. A final chapter is given on the methods of calorimetry and photometry, but no discussion or comparison of the relative value of heating and illuminating power as a test of purity is included. Seeing that illuminating tests are being superseded by calorific, such discussion would have been welcome. Some useful commercial tables are furnished in an appendix.

First Annual Report of the State Department of Health of Massachusetts, 1915. Boston: Wright and Potter Printing Company.

FOR years we have been accustomed to receive the annual reports of the State Board of Health of Massachusetts, the last, that dated 1914 and received here in August, 1916, being numbered the forty-sixth. From time to time we have reviewed them, and given long summaries of parts of their contents. In these volumes there appeared the first reports of the purification of sewage by bacterial means, and from the experiments there detailed there has arisen an immense change in the methods of treating sewage. At the time the Board took up the subject the municipalities of this country were at their wits' ends to dispose of the outflow from the sewers. Sanitary science had condemned the domestic midden and demanded the institution of water-carriage in all our large towns, while at the same time there was an outcry against the fouling of our streams. The Local Government Board prescribed treatment by land, but often there was no land available, and even when there was it was frequently quite unsuitable to act as a filter. Sewage ran over heavy clay lands without undergoing any improvement, while deep draining was not only expensive, but was of little advantage. The advent of the bacterial filter was greeted with enthusiasm, and soon experimental installations sprang up all over the country. A great deal remained to be discovered as to the best conditions of working, but we owe a deep debt of gratitude to the State Board of Health of Massachusetts for establishing the fact that the nitrification of sewage by aerobic organisms was a commercial possibility. It is now perfectly possible to secure an effluent that will not putrify in a stream, and which can be turned into a river of average purity without giving rise to nuisance. We are still far from the ideal standard of purity, but nevertheless immense progress has been made, and the resources of sanitary science are far from being exhausted.

It will be noticed that the title of the volume under consideration is new. The present is not the Forty-Seventh Report of the State Board, but the First Report of the State Department. In 1914 an Act was passed by the Legislature of Massachusetts to create a State Department of Health and to amend the public health laws. This department now exercises all the powers and performs the duties imposed by law on the State Board of Health. The alteration of constitution has involved many changes in administration, and the new department is now organised in the following divisions:—Administration, communicable diseases, hygiene, food and drugs, sanitary engineering, water and sewage laboratories, and biologic laboratories. At present the laboratories are grouped as:—Water and sewage laboratory, Lawrence experiment station, diagnostic laboratory, antitoxin and vaccine laboratory, Wassermann laboratory, and food and drugs laboratory. The cost of the work done has been gradually rising. In 1910 it was 160,000 dols., and in 1916 it was 220,000 dols., not a large sum to cover such a wide field of activities.

Many researches are still being continued at Lawrence. We do not propose to enter into them at length, but may briefly refer to one or two. The combined influence of forced aeration and of growths of algæ—largely *Protococcus*, *Scenedesmus* and *Monas*—has yielded most promising results. Tanks containing a few layers of slate, and subject to air currents, gave stable and well-clarified effluent in 24 hours. Activated sludge has also been under investigation, and 86 per cent. of the samples after three hours' aeration and settling were stable on incubation. There has been an inquiry into the best depth for trickling filters, and although this is not concluded it has been shown that the purification increases much faster than the depth up to a certain point. Probably there is a most efficient depth of filter for each size of broken stone used in the construction of the filter. It has been found that the deeper the trickling filter, up to a certain point, the greater the tendency of the applied water to mix or mingle with the held water, instead of passing by this held water. This tendency to mingle as the filter depth increases, and to push the held water towards the under-drains, is great enough to cause a large percentage of the sewage passing through a 10-ft. filter to be not simply twice as long in passing as in going through a 5-ft. filter, but five or six times as long. Conversely, the rate of the deep filter may, on account of this, be from five to six times that of the shallow filter, with equal purification results.

Sewage purification only occupies a small part of the energy of the department, but it and the germane subject of water supplies are all that lie directly within our province. The health of the community must have greatly benefited by the action of the department during past years, and by the legislation

which it has fostered. It has been specially successful in preventing poisons being sold under the guise of patent medicines without notification of the fact on the label. A few years ago there were many specifics in Massachusetts against the alcohol habit, and some of these contained morphia in quite large doses, so that the drunkard became a morphia maniac—to his very great disadvantage. Now this traffic has been put a stop to, although there is a considerable illicit sale of morphia and cocaine on the streets. Possibly this is due to the craving left by the medicines that have been suppressed.

The best wish we can express for the new State Department of Health is that it may live up to the traditions of the Board which it has superseded, and that with greater resources and enhanced prestige it may continue the prosecution and publication of its researches, for the benefit not only of Massachusetts, but also of the world.

BOOKS RECEIVED.

Flour Milling: A Theoretical and Practical Handbook of Flour Manufacture for Millers, Millwrights, Flour-Milling Engineers, and others engaged in the Flour-Milling Industry. By PETER A. KOZMIN, Editor of *The Russian Miller*. Translated from the Russian by M. FALKNER and THEODOR FJELSTRUP. London: George Routledge and Son, Limited. [Price 21*s.* net.]

The Organisation of Thought. Educational and Scientific. By A. N. WHITEHEAD, Sc.D., F.R.S. London: Williams and Norgate. [Price 6*s.* net.]

Critique des Propulseurs. Par PAUL POPOVATZ. Paris: Gauthier-Villars et Cie.

The Directory and Chronicle for China, Japan, Corea, Indo-China, Straits Settlements, Malay States, Siam, Netherlands India, Borneo, the Philippines, &c. for the Year 1917. Hong Kong: The Hong Kong Daily Press, Limited; London: 131, Fleet-street. [Price 30*s.* net.]

Trade Fallacies. A Criticism of Existing Methods and Suggestions for a Reform towards National Prosperity. By ARTHUR KITSON. London: P. S. King and Son, Limited. [Price 5*s.* net.]

United States Geological Survey. Contributions to Economic Geology. Bulletins. No. 640—B. *Reconnaissance of the Conconully and Ruby Mining Districts, Washington.* By EDWARD L. JONES, Junr. No. 640—D. *Molybdenite and Nickel Ore in San Diego County, California.* By F. C. CALKINS. No. 640—E. *Lode Mining in the Quartzburg and Grimes Pass Porphyry Belt, Boise Basin, Idaho.* By E. J. JONES, Junr. No. 641—B. *The Oil and Gas Geology of the Foraker Quadrangle, Osage County, Oklahoma.* By K. C. HEALD. No. 641—C. *Possibilities of Oil and Gas in North-Central Montana.* By EUGENE STEBINGER. No. 641—D. *Structure of the Vicksburg-Jackson Area, Mississippi, with Special Reference to Oil and Gas.* By OLIVER B. HOPKINS. No. 641—E. *An Anticlinal Fold near Billings, Noble County, Oklahoma.* By A. E. FATH. Washington: Government Printing Office.

Industrial Fatigue in its Relation to Maximum Output By HENRY J. SPOONER. London: Co-Partnership Publishers, Limited, 6, Bloomsbury-square, W.C. 1. [Price 6*d.*]

How to Drive a Motor Car. A Key to the Subtleties of Motoring. Fifth Edition. London: Temple Press, Limited. [Price 1*s.* net.]

Transactions of the Institution of Water Engineers. Vol. XXI. 1916. Edited by PERCY GRIFFITH, M.Inst.C.E., F.G.S., Secretary. London: St. Bride's Press, Limited; New York: D. Van Nostrand Company.

Farming by Motor: All about Farm Tractors and Motor Ploughing. Illustrated Examples of the Work that can be done with Motor Tractors and a Guide to the Selection of Machinery for Motor Tillage. Produced by *The Motor* and *The Commercial Motor*. London: Temple Press, Limited, Rosebery-avenue, E.C. [Price 1*s.* 6*d.*]

Industrial and Manufacturing Chemistry: Part II. *Inorganic. A Practical Treatise.* By GEOFFREY MARTIN, Ph.D., D.Sc. Volume II. London: Crosby Lockwood and Son. [Price 25*s.* net.]

London Shipping, 1917. *The Journal of Commerce* Office, 37, Walbrook, London, E.C. [Price 1*s.*, by post 1*s.* 3*d.*]

Dominions Royal Commission. Final Report of the Royal Commission on the Natural Resources, Trade and Legislation of Certain Portions of H.M. Dominions. London: H.M. Stationery Office, Imperial House, Kingsway, W.C. 2, and at Manchester, Cardiff and Edinburgh; Dublin: E. Ponsonby, Limited, 116, Grafton-street; United States and Foreign Countries: T. Fisher Unwin's Agencies. [Price 2*s.* 6*d.* net.]

THE LANCASHIRE AND YORKSHIRE RAILWAY SHED AT GOOLE.—We regret that, by an oversight, we omitted to mention that the new shipping shed at Goole of the Lancashire and Yorkshire Railway, illustrated and described on page 58, *ante*, was constructed by Messrs. Edward Wood and Co., Limited, Ocean Iron Works, Ordsal Lane, Manchester. They were the principal contractors, and carried out all the structural and builders' work. The electric travelling cranes, also illustrated, were not only constructed but designed by Messrs. Craven Bros., of Reddish.

INDUSTRIAL NOTES.

AT the request of the Pensions Authorities the Minister of Labour is establishing a number of Advisory Wages Boards, and the Board for the County of London has now been formed. The boards consist of representative employers and workmen sitting with an impartial chairman. Their duty will be to consider the wages to be paid to disabled sailors or soldiers for particular work, and either an employer or a disabled sailor or soldier can submit a case to the board for an authoritative opinion on this point. Anyone in the County of London who wishes to submit a case to the Advisory Wages Board should make application to Mr. T. Park, clerk to the board for the County of London, Martlett House, Bow-street, W.C. 2. Forms of application may be obtained at any Employment Exchange in London. The first meeting of the board to hear cases was held yesterday.

The number of women placed on the land up to the end of June was 5,243, and with regard to the Women's Army Auxiliary Corps, 1,997 clerks and 1,200 domestic workers have been called up by the War Office up to the end of June.

We learn that, previous to the changes in the Government, Dr. Addison had invited Sir Thomas Munro, County Clerk of Lanarkshire, to accept the position of Chief Director in the Labour Regulation Department of the Ministry of Munitions in order to supervise the work in connection with general labour matters affecting wages and disputes, and, in particular, the formation, as soon as possible, of representative committees of employers and workpeople.

Sir Thomas Munro has expressed his readiness to accept the invitation, subject to the consent of his council being obtained and to his being relieved of other important public duties. He was a member of the Commission on the Dilution of Labour for the Clyde and Tyne Districts, and is at present Labour Adviser for Scotland to the Admiralty Shipyard Labour Department and the Ministry of Munitions. He is also an Assessor to the Central Board of Control (Liquor Traffic).

We are dealing in a separate article in the present issue with the Commissioners' report in regard to Industrial Unrest.

In a report recently issued by the Chief Registrar of Friendly Societies, we read that the total membership of these societies with branches was 2,955,424 in 1915, as against 2,935,272 in 1914, the funds amounting to 32,181,660*l.* in 1915 and 31,024,699*l.* in 1914. Branchless friendly societies had a membership of 3,829,477 in 1915, as against 3,888,964, the funds being 24,822,979*l.* and 23,870,428*l.* respectively. Collecting societies had 8,252,070 members in 1915 and funds totalling 12,599,765*l.*, an increase compared with 1914. Co-operative societies' members numbered 3,736,589, as against 3,480,756, and the funds were 63,177,953*l.* compared with 57,968,671*l.* The membership of building societies increased from 628,885 to 633,877, and the funds from 51,105,750*l.* to 51,163,755*l.* Trade union membership rose from 3,261,250 in 1914 to 3,438,642 in 1915, the funds being 7,051,507*l.* in 1914 and 8,638,792*l.* in 1915. The registrar comments upon the high cost of management which prevails. In one instance out of an income of 2,190*l.* some 2,070*l.* was spent on management. The sales for 1915 of co-operative stores amounted to 106,000,000*l.*, showing an increase of 17,000,000*l.* over the figure for 1914.

The operatives of Lancashire, says *The Textile Mercury*, are displaying an astonishing persistency in forcing up the rates of pay beyond the standard which existed prior to the war. Rates are now 20 per cent. above those of 1914; youthful workers in the mills are earning weekly sums that are nearly twice the amount received for such labour a few years ago, and the Amalgamated Association of Card and Blowing Room Workers are asking employers to put on another 20 per cent., and the Amalgamated Association of Operative Cotton Spinners are demanding an increase of 30 per cent., to bring their rates 50 per cent. above those of the pre-war days. These applications, if granted wholly or partially, will be followed by similar claims from weavers and allied workers.

The prices of cotton goods have not advanced to anything like the extent of food prices, while the cost of producing them has gone up enormously, due to higher prices of raw material and labour and administrative expenses. If the operatives succeed in their underlying intention to secure a 50 per cent. advance on 1914 rates, it is clear that the Lancashire trade, of which 80 per cent. has to be transacted among foreign purchasers, will be seriously jeopardised. How long can such earnings be maintained, either before or after the end of the war? Although the card-room workers have been the first in the field with applications for advanced rates, the spinners are evidently going to set the pace towards a 50 per cent. increase—and perhaps more—and their earnings, which varied from 2*l.* to 4*l.* before the war, will come to range from 3*l.* to 6*l.* Women roving-frame workers with 32*s.* per week before the war will rise to 48*s.*; and we shall have boy piecers receiving 30*s.* to 40*s.* per week! We agree, adds the journal, that if this could be maintained it would be an excellent thing for the economic interests of factory family life in Lancashire; but when free competition in the world's markets reasserts itself, the Lancashire cotton industry will find itself in a very peculiar position, to say the least. Against the growing strength and influence of labour, locally and nationally, employers will be left with the difficult task of finding a way out of an industrial and commercial dilemma which will have been raised about their heads.

On the other hand, we read in *The London and China Telegraph* that H.M. Commercial Attaché at Yokohama writes, under date June 1, drawing attention to schemes which are being devised for the amalgamation on a large scale of the various cotton-spinning interests in Japan, with a view to consolidating the position of the cotton textile industry in that country and enabling the mills to retain their hold on foreign markets against the competition of British, American and German goods which will no doubt supervene at the close of the war. According to a recent issue of the *Japan Advertiser*, most cotton spinners in Japan have recently made immense profits owing to the extraordinary boom in the cotton yarn and cotton textile markets. A firmer footing has been gained in many Oriental countries which were considered to be the permanent markets of British or German spinners. It is felt, however, that this is only an abnormal condition brought about by the war, and that, in order to meet competition after the war, it is necessary not only to raise the standard of Japanese goods, but also to improve the financial position of the industry by the formation of a combine. Not only spinning mills, but weaving, printing, bleaching and dyeing mills will be included in the combination. *The Japan Advertiser* goes on to give instances of amalgamations of large spinning companies which have already been, or are in process of being, effected; one such amalgamation, it is said, will have a total of 540,000 spindles in operation. Eventually, it is expected, Japan's cotton mills will be concentrated into five large interests, although, naturally, there may remain a few mills operated by independent capitalists. The attaché adds that the cotton industry is by far the best organised industry in Japan, and that the amalgamation of these large concerns will certainly tend to reduce expenses and obviate needless competition.

Mr. Samuel Rea, president of the Pennsylvania Railroad System, issued on June 30 the following statement regarding the decision of the Interstate Commerce Commission in the 15 per cent. advance rate case:—

"I am amazed at the reasoning, and discouraged by the conclusions, in the rate decision. The Eastern railroads are the great terminals for the whole country, and absolutely require the 15 per cent. increase immediately. The Pennsylvania system is indicative of conditions on the railroads in Eastern territory, and its operations verify the estimates made for the commission.

"The five months ended with May show an increase of about 9 per cent. in gross earnings, but a decrease of about 27 per cent. in net operating income, or nearly 10,500,000 dols. compared with 1916. Costs of labour and materials are still rising, especially fuel coal, which will be increased by several millions over what was estimated in the rate case.

"Notwithstanding all the railroads are doing in co-operation with the Government (and no other interests are doing more), the country will realise that there will probably be more congestion next autumn and winter than it has heretofore experienced. We are bending every effort to meet that situation, but instead of putting the railroads in a position where they can give substantial assistance by additional facilities and equipment, their credit will be seriously limited by this decision, and the country at large must of necessity suffer.

"The commission estimates a return of only 4.89 per cent. for the year ending June 30, 1917, on the road and equipment provided for public use by the Eastern railroads, and yet declines to grant a reasonable increase in rates. What credit or progress can be based on any such inadequate return?

"The experience of the weak condition of the railroads for five years prior to 1916, with practically no new mileage constructed, and insufficient terminal facilities, is utterly ignored.

"I dislike to criticise any Governmental decision, but the people should know why it is impossible to provide adequate facilities and service, which are

imperatively required for this growing country, and should understand how unjustly the Eastern railroads are being treated."

Of the numerous problems of the day in the United States, says *The Iron Age*, some of the most serious are connected with the migration of negroes from the South, and the people of the South, in dire need of negro labour to harvest crops and work in many manufacturing plants, have had to adopt drastic measures to keep the negroes at home. In some districts, heavy licences have been imposed on agents of railroads and other companies seeking negro labour. In Alabama negroes have been fined and given hard labour sentences for the alleged offence of attempting to entice men to go North.

The migration leaves problems in its trail and takes others to the community to which it moves. Not only is the South deprived of the labour of men who go to the North, but also it is compelled to care for women and children left behind. Desertion is not universal, but there is enough of this lack of responsibility on the part of the blacks to cause much annoyance and no little outlay to the whites.

In the North, some negroes are proving good workmen at steel and other plants where the test is severe, but many are shiftless and constantly moving from one town to another. The climate of the Northern States is causing among them many deaths through tuberculosis.

The lure of the high wages is the principal cause of the negroes leaving their southern home, and it will continue to have a powerful influence until wages in the North and South more nearly approach equality.

According to *The Electric Railway Journal*, New York, the British Columbia Electric Railway has found that the war has had no appreciable effect upon the company's *personnel*. Although a large number of men have enlisted, the standard of efficiency has been well maintained in the numerous classes which require skilled labour. Approximately 21 per cent. of the company's employees have left the service to join the military or naval forces, or have taken up the manufacture of munitions. Their places have been filled, until they return, or for the duration of the war, by temporary help. The company's records show that the enlistments for military service among the various branches of the company's employees are as follow:—Platform men, 19 per cent.; shopmen, 13 per cent.; electricians, 20 per cent., the latter figure including sub-station operators, from which particular class the largest percentage of enlistments occurred, no less than 36 per cent. of the company's sub-station men having joined the colours for serving overseas.

The Minister of Munitions has issued an Order, dated the 24th inst., by which all iron ore mines in the counties of Cumberland and Lancaster pass into the possession of the Ministry of Munitions.

The Gas Committee of the Manchester Corporation, says *The Manchester Guardian*, has approved of the annual report to be submitted to the City Council at the council meeting on August 1.

The income from all sources for the year was 1,002,570*l.*, against 935,843*l.* for the preceding year. On the other hand the expenditure was higher—852,758*l.*, as compared with 744,948*l.* The gross profit was 149,812*l.*—last year it was 190,895*l.*—and the net 93,780*l.*, against 141,234*l.* There was a deficit of 34,009*l.* in last year's account. This has to be met. Then the committee have been asked to contribute 50,000*l.* in aid of the city rate, and the sum of 61,047*l.* is needed for sinking fund for redemption of loan debt. As, therefore, the net profit on the year's work is insufficient to meet these claims, the committee propose to carry forward an adverse balance of 53,951*l.*

In the course of the year gas was sold to the extent of 5,561,137,000 cub. ft., a decrease of 2.44 per cent. on the figures for the year before. The cost of coal and oil per ton carbonised was 18*s.* 1.39*d.*, as against 14*s.* 9.60*d.* for the year before, while the income from residual products rose to 12*s.* 5.71*d.* per ton, as compared with 10*s.* 0.10*d.* The committee regret that, owing to the increased cost of oil and other materials and of the war bonuses to employees, they have been compelled to recommend an advance of 6*d.* per 1,000 cub. ft. in the price of gas to all consumers. This advance, together with that approved by the council on May 5, 1915, makes a total increase in the price, consequent upon the war, of 1*s.* per 1,000 cub. ft.

There was an estimated decrease of 110,000,000 cub. ft. in the consumption of gas owing to the operation of the Summer Time Act from May 21 to October 1. The decrease was equal to 1.80 per cent. on the annual consumption.

A book of statistics concerning the gas undertaking has been compiled by the superintendent, Mr. F. A. Price. It gives the excess of assets over liabilities as 2,319,247*l.* Since the business passed into the hands of the Corporation 73 years ago the department has given 3,317,174*l.* in aid of city rates.

CONDENSER TUBE CORROSION.

To the Editor of Engineering.

SIR,—I have read in your issue of July 13 the very interesting and very complete article by Mr. William Ramsay on "Condenser Tube Corrosion." The corrosion of condenser tubes is a question which preoccupies the mind of all French engineers whose duty it is to keep marine engines, both those of warships and those of merchant vessels, in a good state of maintenance and repair, and it is an undeniable fact that when the difficult problem of the conservation of these tubes has received a satisfactory solution a great service will have been rendered to navigation. It is incumbent upon all to contribute to that end, and, in this view, I beg to ask you to put the following facts before Mr. Ramsay.

Formerly—over twenty years ago—the Compagnie des Messageries Maritimes, in the use it made of tubes of French manufacture, found no abnormal wear or corrosion in its condensers; the nests of tubes were replaced only after a more or less lengthy period of years, the tubes having simply become regularly thinner by long service.

Condenser-tube sickness broke out rather suddenly in about the year 1895: it fell only upon the tubes of more recent French manufacture. The ships were the same, they ran on the same routes and between the same harbours, the engines also were the same, but, nevertheless, the newer tubes became rapidly perforated, sometimes on the first trip, whilst the tubes of the older class, and still in service, continued to stand well.

We thereupon experimented with British Admiralty tubes. Their wear was longer than that of the tubes of more recent French make, but was much inferior to that of the older tubes. The replacing of tubes became more and more frequent, leading to considerable expenditure.

Owing to the increase in the use of electrical installations on board we immediately looked for a possible influence of current leakages, but our researches very rapidly showed us that the cause of the evil was not in that direction.

We thereupon asked a chemical engineer, Mr. Guillemin, to study the question of corrosion, and we gave him three tube specimens, without adding any data either as regards their make or as to the manner in which each behaved in service. One was from a tube of the older French manufacture, one from a British Admiralty tube, the third being from a French tube of recent make.

After ascertaining that the alloys of the three were practically the same, Mr. Guillemin examined the tubes micrographically, and found that the texture was essentially different in the three specimens. That of the French tube of earlier manufacture was almost entirely amorphous; in the British tube it was made up of small crystals, and in the tube of recent French manufacture of large crystals. In this latter the length of some crystals was equal to the thickness of the tube—they ran through the thickness.

The research led Mr. Guillemin to formulate an electro-thermic theory showing that a tube will better resist corrosion when its texture is more extensively amorphous, and that the three specimens would of a necessity behave very differently, the most resistant being the tube of former French manufacture, and the least resistant being the one of recent French manufacture.

This conclusion was in complete agreement with the results shown in actual service, which results were not indicated to the experimentalist, in order not to influence his research.

The texture of brass varies with the extent of cold working and the temperature of annealing. The physical properties of the metal, and notably its ductility, vary at the same time, this latter property being greater for the crystalline than for the amorphous texture. It might, therefore, have been expected that the tubes of ductile brass would become more rapidly scored than the others. We had, in fact, noted that the tubes sufficiently ductile to allow the tightening of the ferrule in the tube plate to deform the metal and leave an impression on the tube were more rapidly and more extensively perforated than those of hard and brittle metal which did not allow of such a deformation.

An example is given in Mr. Ramsay's article which appears to corroborate the above; it is that of the furrowed tube, in which the furrowed portion—the texture of which was certainly different from that of the smooth portion—was the one almost exclusively corroded.

It may, I think, be interesting, and perhaps also useful, to Mr. Ramsay to receive the above account.

Yours faithfully,
E. RAYMOND,
Chief Engineer,
Compagnie des Messageries Maritimes.
1, Rue Vignon, Paris.

ASCERTAINING THE CENTRE OF GRAVITY COMMON TO SEVERAL WEIGHTS.

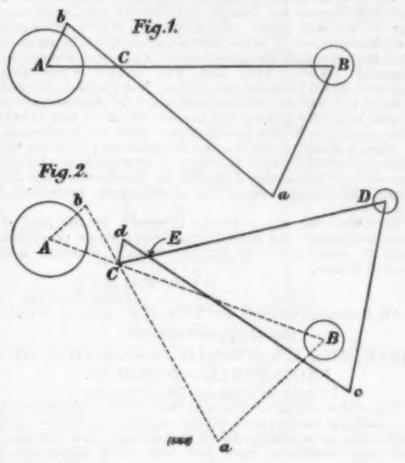
To the Editor of Engineering.

SIR,—It is very many years since I devised the following geometrical method of combining the centre of gravity of various items on ship-board, but although I believe it is now known in many shipbuilding offices, it has never, to my knowledge, been published.

In Fig. 1 the centres of gravity A and B of two bodies are known, as well as their weights. It is required to ascertain their common centre of gravity.

Draw parallel lines A *b* and B *a* in opposite and any convenient directions. Make A *b* represent, to any convenient scale, the weight of B, and B *a*, to the same scale, that of A. Join A B and *a b*. They will cut at C, the required common centre of gravity.

In Fig. 2 D represents the centre of gravity of a third body. A line C *d* representing the weight at D is drawn through C; and D *c* is drawn, parallel to it, of a length representing the combined weights of which C is the



centre of gravity. Lines joining C D and *c d* cut at E, the common centre of gravity of A B and D.

E forms a new starting-point for further lines if other weights are to be considered.

The work is done on a piece of tracing paper, and the position of the final centre of gravity is pricked through to the drawing beneath.

Each pair of parallel lines must be to a common scale, but this need not be the same as that used for other pairs.

Yours faithfully,
C. H. WINGFIELD.

"SIX MONTHS OF RAILWAY ACCIDENTS."

To the Editor of Engineering.

SIR,—I have seen in your issue of June 1, 1917, page 529, an article entitled "Six Months of Railway Accidents," in which stress is laid on drivers running past signals. If a writer from this side is not assuming too much, he would be pleased to state his observations. No doubt you are aware that we, on this side, are often chronicling these sad events.

In reading your and other British journals the writer has noted that over-running signals has increased with the same ratio as increase in size of boiler. It seems to him that the Board of Trade, managers, and locomotive designers do not recognise this handicap. The driver has manifold duties other than keeping his eyes on the signal, and his danger is augmented by smoke "trailing back."

The boiler is raised to a greater ratio than the increase in size due to a desire to keep the fire-box clear of the running gear. Clearance of tunnels prevents the stack being raised, and with the footplate raised, the driver is placed close to the line of trailing smoke, which on striking the cab eddies around the spectacle glass. Thus, it can be seen, I trust, if he misses the signal due to a flurry of smoke and cinders his vision is fixed on a line with the signal to "pick it up," that he does not observe the obstructions until too late to stop, or he may misread the colour of the light.

In noting engravings of recent heavy-power locomotives put into commission on your roads, the stack seems to the writer only about 6 in. above the boiler; in fact, in line with the roof of the cab. The superheater and brick arch eliminate the necessity for sharp exhaust. Hence the large nozzles do not give sufficient blast to throw the smoke and cinders in the air when running at high speed, and the blinding effect is intensified when shut off. Thus, it can be seen why signals are run down when approaching interlocking plants.

It seems to the writer that the drivers, fearing to get the ill-will of the "higher up," say as little as possible and do not bring this point to the front. Furthermore, the drivers, home and abroad, fearing they will be criticised if they "lose time," are tempted when they "lose their bearing" to "go it blind," as was shown at Aisgill, where the driver was out on the front end adjusting the lubricator. Also on the Canadian Pacific during a blizzard in a large yard the driver admitted he could not see, and collided with a switch engine.

If the big locomotive "fever keep raging" the only remedy the writer sees to avoid these distressing accidents (which will occur as sure as bad weather sets in) is to put automatic indicators on the engine, as the writer suggested before the big boiler was introduced. According to your article the President of the Board of Trade recommends automatic control of the brakes. The writer does not

think such costly machinery necessary. If the driver can get a duplicate indication of the signal, he can rest assured the brakes will get attention. Any automatic control of the brakes on a steam locomotive to the writer is "monkeying with a buzz-saw," as operating conditions are not similar to those on the undergrounds.

The following is an extract from a communication the writer sent the Minnesota State Railroad Commission some time back touching in part on this defect, to wit:

"With the large engines now in use the engineman in the rear of boiler is similar to a motor man driving a car from the rear end, leaning out over the side endeavouring to see his way. Even if the engineman could keep his head out in below zero weather, his only resource is to look through the glass, which is partly obscured by escaping steam. This fact was shown when first eighteen (train) overran the signal, being unable to read it until too late to prevent running by. And certain it is that second eighteen did not see signal or tail lights. This danger will not be overcome until the engineman is placed ahead, in front of escaping steam, with double glass sealed to prevent frosting, of which the ideal is on the electric locomotives on the St. Paul road over the Rocky Mountains, which, no doubt, your commission has seen."

Therefore the writer thinks it would be the part of wise policy to "go after" electricity, oil or powdered coal to overcome the smoke—British, Colonial and United States.

Very truly yours,
JOHN FRANCIS.

16, Rivington-street, New York, N.Y., July 3, 1917.

WANTED: A NATIONAL ASSOCIATION OF ENGINEERING FOREMEN.

TO THE EDITOR OF ENGINEERING.

SIR,—One result of the war has been recognition of the national importance of the engineering trades and tradesmen as a whole, but I feel certain that foremen and shop managers have not been fully appreciated by employers and Government authorities. The rank and file of workmen have, through their organisations, received a very full measure of attention, mostly in the important matter of wage rates and conditions; draughtsmen have within the last eighteen months formed an association which embraces quite 80 per cent. of the profession, but shop managers and foremen are at the present time comparatively quite a disorganised body. Both the men and draughtsmen have made urgent representations to the Government on the vexed question of leaving certificates, and although I am not at the moment in possession of the final terms of the amending Bill which will be shortly placed before Parliament, I am told even draughtsmen—a small class—are being considered. Shop foremen are, especially in Government factories, under all the disabilities appertaining to workmen, without any corresponding advantages, and while private firms in many cases have provided war bonuses and special emoluments based on the output of the shops, in others no commensurate increase has been made, taking into account the additional responsibilities and onerous duties of a foreman whose staff now is twice as big as before the war, and working day and night. It is common to foremen here to receive less than the men, and I think it time for foremen to combine—not, perhaps, on trade union lines—to maintain their status in the engineering trade. I am aware of the work of the London Foremen's Association, and also certain provincial bodies, but they have not taken concerted action on questions of immediate importance. The Woolwich Association appears to be a friendly society, and, therefore, of no other value.

I shall be pleased to hear from other engineer foremen. Our association here, although young, is doing good work, but needs co-operation with other similar bodies.

I am, yours faithfully,
A MEMBER, R.A.F. FOREMEN'S ASSOCIATION.

The Royal Aircraft Factory Staffmess, South Farnborough, Hants, July 25, 1917.

ENGINEERS AND THE ROYAL NAVY.

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with interest the letter on "Engineers and the Royal Navy" in your issue of July 13, and would mention that I know of several cases where fully qualified marine engineers were patriotic enough to join the Royal Naval Reserve before the war as engine-room artificers, with the result that junior officers who had previously been below them in rank are now considerably above them in position and responsibility.

The engine-room artificer is the counterpart of the mercantile marine engineer, and carries out precisely the same duties, and if, as it is suggested, the engineer section of the Osborne-trained officer has been a failure, then I think sufficient brains would be found amongst the artificer class to fill all the engineering positions of the Royal Navy both afloat and ashore.

It seems to me that the simple fact of joining the Navy as an engine-room artificer is sufficient to condemn a man as being an inferior person who is necessarily unfit for a position of responsibility and quite unsuited for the society of upper-deck officers.

The Royal Navy would, I think, be better served if the engineering departments were run on the same lines as the mercantile marine. The terms "artificer engineer" and "engine-room artificer" should be done away with, and all candidates entered as junior engineers, promotion through the various grades being given for service plus ability in practical and theoretical work shown while afloat and at examinations.

This, of course, would necessitate an engineers' mess and an improvement in the accommodation at present provided. The results, however, would, I feel sure, fully justify any expense incurred by increase of pay, and result in a far better class of men joining the Navy than are doing so at present.

It is within my knowledge that commissions have been given to persons without the slightest marine experience and very little other engineering practice, and this, together with the fact that no examination is held, compels one to think that in this, as in some other departments of the Government, the chief qualification for an appointment often is to know nothing whatever of the particular work the candidate will be called upon to perform.

I am, sir,
EXTRA FIRST-CLASS ENGINEER.

PORTABLE AIR COMPRESSOR SET.

CONSTRUCTED BY MESSRS. BROOM AND WADE, LTD., ENGINEERS, HIGH WYCOMBE.

(*For Description, see opposite Page.*)

FIG. 1.

BACTERISED TOWN REFUSE.—In our issue of June 7, 1907, we brought to the notice of our readers a pulverising machine, called the "patent lightning crusher," which reduces practically unsorted house refuse to a uniform coarse mould which, on leaving the machine, is used as a fertiliser. Such machines have been adopted for use by a number of municipal councils, both in Great Britain and abroad, with very satisfactory results. Captain Furse, a director of the Patent Lightning Crusher Company, Limited, 29, Mincing-lane, E.C., and the original patentee of this machine, has recently perfected a process of bacterising this town refuse and turning it into a fertiliser of great value. The pulverised refuse is converted by the bacteria into soft black powder with a wholesome and agreeable smell of humus. An official chemical analysis made at one of our agricultural colleges shows that this manure contains about 3 per cent. of nitrogen, 3 per cent. of phosphoric acid and 1½ per cent. of potash. The sample contained when analysed nearly 20 per cent. of moisture, which could be easily reduced to 3 per cent. or 4 per cent., thus materially increasing the relative percentage of plant foods. Practical experiment has endorsed the analysis. One great advantage of this fertiliser is that the "raw material" can be obtained within our own boundaries without need of importing any of its constituent parts, nothing being used in its composition but town refuse.

JOHN FRITZ MEDAL PRESENTED TO DR. H. M. HARE.—The John Fritz medal, which was awarded last January to Dr. Henry Marion Hare for his "investigations in metallurgy, especially in the metallography of iron and steel," was presented to him at a meeting held on May 10 in the United Engineering Societies' Building, New York. A full account of the proceedings is contained in the bulletin for July of the American Institute of Mining Engineers.

DIESEL ENGINE USERS' ASSOCIATION.—The June meeting of the Diesel Engine Users' Association was held during the week in which the Incorporated Municipal Electrical Association was holding its meetings in London. This arrangement was made for the convenience of engineers in the provinces, who in some cases are members of both associations, and who in consequence of being at a long distance from London may not have frequent opportunities of attending to discuss Diesel engine matters. There was a large attendance, including a few visitors interested in the association's work, who had been invited by the committee to attend on this occasion. The election of several new members and "subscribers" was announced. The result of the lengthy negotiations with the Inland Revenue authorities in the matter of the allowance for depreciation of Diesel engines for income-tax assessment was reported. The new rate allowed for this purpose for Diesel engines is 10 per cent., and this increased allowance is to remain in force for three years after the cessation of the war, when either party is to be at liberty to claim a revision. Considerable interest had been aroused by Mr. Geoffrey Porter's paper on "Tar Oil Fuel and Diesel Engines," which had been read at the previous meeting, and in the course of the discussion which took place at this following meeting a further amount of useful information on the subject was forthcoming. The question of the influence of sulphur in fuel oils had been referred to in Mr. Porter's paper, and, in response to requests received from several quarters, the president announced that reprints of the report by Dr. E. Graefe on "The Influence of Sulphur in Liquid Fuels in Internal-Combustion Engines," which had been circulated among the members in February, 1915, would again be sent out to members and "subscribers of the association."

PORTABLE AIR COMPRESSOR SET.

CONSTRUCTED BY MESSRS. BROOM AND WADE, LIMITED, ENGINEERS, HIGH WYCOMBE.

Fig. 2.

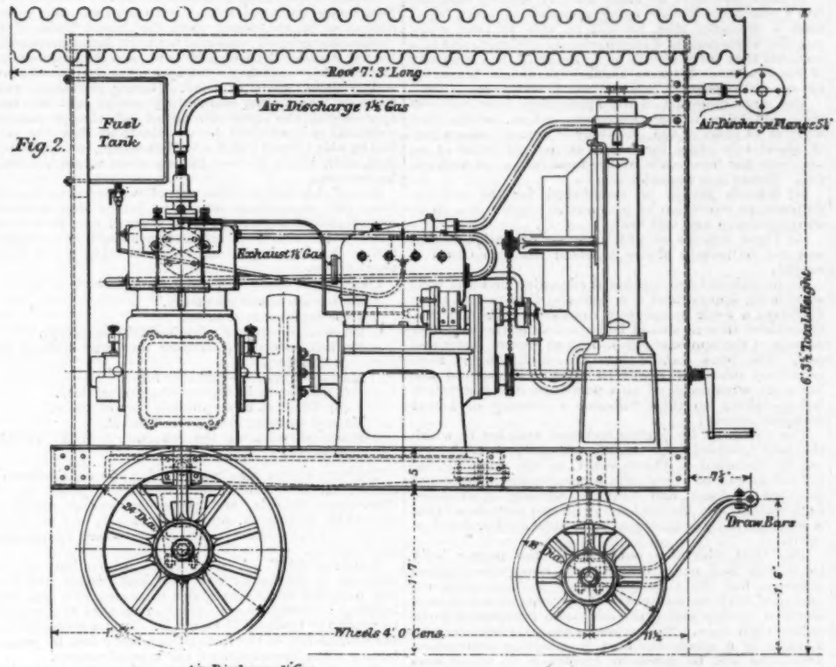


Fig. 3.

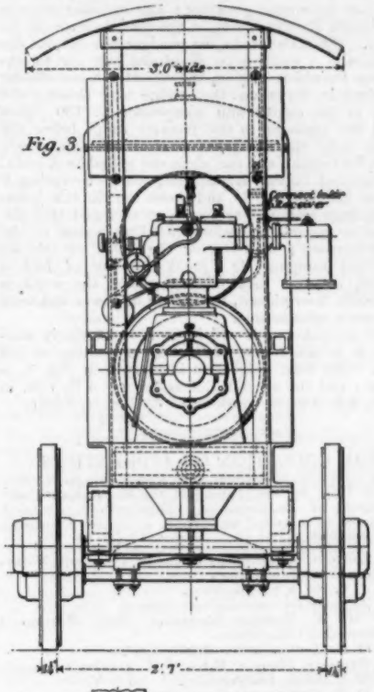


Fig. 4.

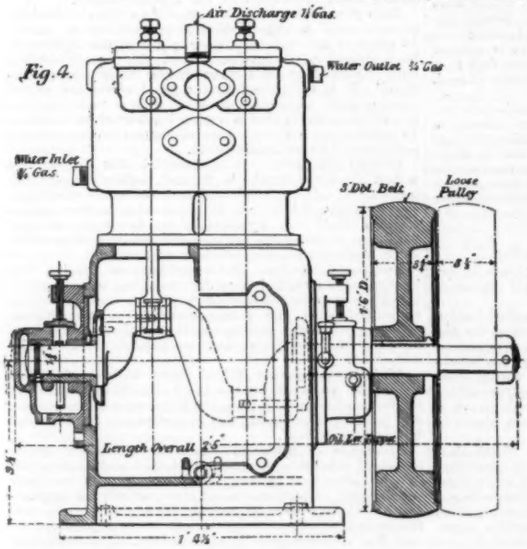


Fig. 5.

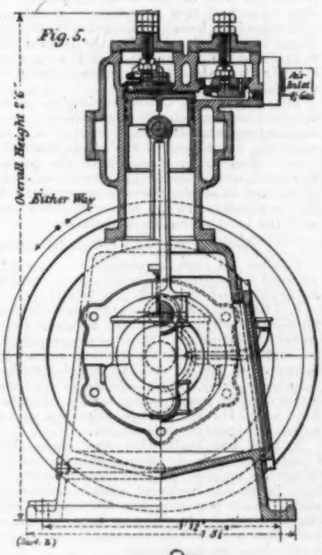


Fig. 6.

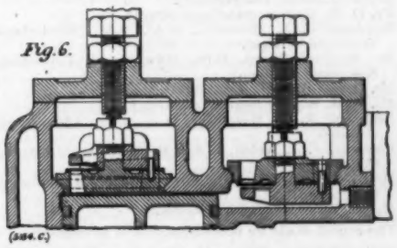
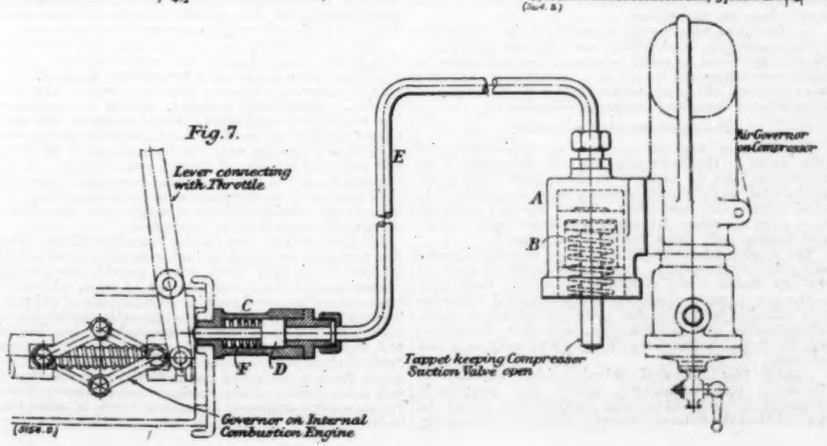


Fig. 7.



WE illustrate in Fig. 1, on the opposite page, and Figs. 2 to 7, on this page, a two-cylinder portable air compressor, built by Messrs. Broom and Wade, Limited, High Wycombe. The compressor is direct-coupled to a Simplex oil engine, both being mounted on a cast-iron sub-base; this base is supported on the portable truck at three points, and is free to swivel, so that while the perfect alignment of the engine and compressor shafts is assured, any deflection or bending that would take place in the truck frame would not affect the engine and compressor shafts. A radiator and fan are fitted in front of the truck, the cooling water first passing through the compressor to the engine. Figs. 2 and 3 are side and end views of the portable set, showing the general arrangement and principal dimensions.

The air compressor, illustrated in Figs. 4 to 6, is of the vertical single-acting type, having two cylinders, each 4 in. in diameter for a 5-in. stroke, and particularly adapted for use in a portable plant. The cylinders are thoroughly water-jacketed, there being no pockets in which stagnant water can remain. The suction and delivery valves, Fig. 6, are both automatic, of nickel steel and of the plate type. Careful attention has been given to lubrication, which is automatic throughout. The two bearings of the crankshaft are oil-ring lubricated, the oil flowing into centrifugal throwers on the crankshaft; it is then carried to the crank-pins through holes drilled in the crankshaft (see Fig. 4). The oil is collected in the base of the crank chambers and is thrown by means of suitable throwers on the connecting rod into a special channel on the side of the crank-case and returned to the oil-ring bearings, a continuous flow of oil being thus obtained.

The compressor will deliver 45 cub. ft. of free air per minute, at 950 r.p.m., to a 100 lb. pressure.

The engine is fitted with a patent governing device. When the desired pressure is reached in the receiver, the air passing through the auto-governor on the compressor is admitted to the small cylinder A,

Fig. 7, containing the plunger B, which, acting on the suction valve of the compressor, lifts and holds the valve from its seat until the pressure falls in the receiver. This puts the compressor on a light load. In order that both compressor and engine may be controlled simultaneously, a small cylinder C, Fig. 7, is fitted on the engine governor; this cylinder contains the plunger D, which acts on the throttle lever of the engine. When the air in the receiver has cut out the compressor, a small pipe E admits the air to the plunger D, which acts on the throttle lever, closing the throttle valve on the engine and slowing the speed of the engine and compressor to 150 r.p.m. When the pressure in the receiver drops below the desired point the air governor starts the compressor under load again, and the air in the cylinders A and C is exhausted to the atmosphere, when the spring F returns the plunger D and frees the throttle lever. The springs and port areas are so arranged that the engine is speeded up before the load comes on the air compressor; by reducing the speed of the set when not pumping air a great economy of fuel is effected, and on rock drilling, where the work is necessarily intermittent, the saving in power and wear and tear is considerable.

This portable set, as will be seen, is extremely compact; it is practically noiseless when running at full speed. The total weight, as illustrated in Fig. 1, is 16 cwt., and the overall dimensions are 6 ft. 3 in. in length, 3 ft. 3 in. in width and 6 ft. 3 in. in height.

THE EDUCATION OF APPRENTICES.

THE following gentlemen were appointed, on November 24, 1916, by the Council of the North-East Coast Institution of Engineers and Shipbuilders, to be a committee to consider and report upon the Education of Apprentices:—

Mr. Herbert B. Rowell, M.Inst.C.E., President, North-East Coast Institution.
Mr. J. T. Batey (shipbuilder).
Mr. Alfred Harrison (marine engineer).
Mr. M. H. Horsley (chairman, West Hartlepool Education Committee).
Mr. G. B. Hunter, D.Sc. (shipbuilder).
Mr. Summers Hunter, M.Inst.C.E. (marine engineer).
Mr. M. C. James (shipbuilder).
Mr. D. B. Morison (marine engineer).
Principal V. A. Mundella, M.A., B.Sc. (Sunderland Technical College).
Mr. Percival Sharp, B.Sc. (Director of Education, Newcastle-on-Tyne).
Mr. Gerald Stoney, B.A., F.R.S. (engineer).
Mr. R. J. Walker (marine engineer).
Professor R. L. Weighton, M.A., D.Sc. (Armstrong College).
Professor J. J. Welch, M.Sc., M.Inst.C.E. (Armstrong College).
Mr. C. Williams (secretary, Northumberland Education Committee).
Mr. E. W. Fraser-Smith, secretary.

The report made by this committee is as follows:—

Report of the Committee on the Education of Apprentices.

To the Council of the North-East Coast Institution of Engineers and Shipbuilders:

GENTLEMEN,—At a council meeting of the Institution, in November, 1916, a memorandum on the education of apprentices was submitted by your secretary, and the principles set out therein were adopted. A special committee was appointed to draft and submit to the council a detailed scheme for the carrying out of these principles. This committee met on December 6, 1916, and subsequent dates, and considered the matter from all points of view, and now beg leave to submit the following report. In order to make this report a complete one, we quote in full the memorandum by your secretary and the terms of reference to the special sub-committee.

Memorandum by the Secretary.

Having regard to the active interest taken and the prominent part played by the Institution in the education of apprentices during recent years, and bearing in mind the discussion aroused by the introduction of a paper* on this subject during session 1915–16, your secretary ventured to believe that the present time might be considered opportune for the Institution to make some definite statement on the matter. With this end in view, the following notes and recommendations have been drawn up and submitted in draft:—

One of the future factors of the well-being of the engineering and shipbuilding industries is the continuous supply of suitably trained men for every position, from the lowest to the highest. It is not only necessary that they should have a knowledge of the industry as at present practised, but also that their education should enable them to seek and adapt new ideas so as to meet successfully the ever-changing conditions which affect its development. If the supply of such men is not forthcoming in the ensuing years, then inevitably it will be found that keener and better-educated competitors will reap the fruits of scientific and industrial research, and that our industries will languish and finally perish. To secure this object the apprentice to the trade must receive a suitable theoretical and practical training, and his whole mental outlook must be broadened. This can only be secured if the employer considers that he is under a very strong obligation to provide opportunities for his apprentices to receive such training during the whole of their apprenticeship, whatever difficulties may have to be faced in the organisation of labour in the works.

If such provision be made then it follows that the boy's education before being apprenticed must be of such a character that he will be able to take every possible advantage of the opportunities offered, and it is essential that there should be no break in the continuity of his education between leaving school and beginning his apprenticeship.

The large majority of the apprentices have received their education in an elementary school, which they leave at 14 years of age, and there is in most cases a gap of about two years for which at present little or no provision has been made by the local education authorities. Hence it is desirable that—

(*a*) Schools should be established for the suitable preparatory education of prospective apprentices up to apprenticeship age, and that

(*b*) These schools should have an educational aim, and not be merely places in which the trade itself is taught.

To provide for the continued education of these boys after being apprenticed it is essential that two or three half-days a week be spent in suitable schools and that attendance thereat should be regarded by the employer as part of the apprenticeship, both as regards hours and pay. The boys coming into the works direct from secondary schools at about 16 years of age should also have the advantages of this part-time day instruction before taking up their full-time university or higher technical course.

The nature of the higher technical training to which the best qualified boys might eventually proceed need not be discussed at the moment, as the first essential for the success of every such scheme is the provision of qualified students, and there are already in existence such colleges and institutions which can provide all that is required in this connection with little further development.

The local education authority is the proper body to initiate and carry on all such apprentice-training schemes, but the employers must work in close co-operation with the authorities if the schemes are to have any real vitality and if the education provided is to be on the right lines. Such schemes can only be successful if there is a guarantee that in selecting apprentices preference will be given by employers to those boys who have had this preparatory training. Where one such school has been established in the district, experience shows that the demand for the trained boys is greater than the supply, proving that the employers find it is in their own interest to encourage the provision of such schools.

The North-East Coast Institution of Engineers and Shipbuilders has always maintained a keen interest in engineering education, and it is in a position to urge upon the employers of the North-East Coast to make every effort to encourage both the pre-apprenticeship and continued education of apprentices in their respective areas, and to advise them to appoint the Institution as their representative and to act in a consultative capacity with the local education authorities.

Terms of Reference to Special Committee.

1. That all such apprentice-training schemes as are referred to herein be carried out by the local education authorities and the employers jointly.

2. That the Institution urge upon the local education authorities within its district to make provision for the suitable preparatory education of prospective apprentices in engineering and shipbuilding works by the establishment of junior day technical schools within their respective areas. Such schools to be places providing a two or three years' course for the suitable education of boys up to the age of apprenticeship, and not places in which the trade itself is taught.

3. That the Institution urge upon the North-East Coast employers in the engineering and shipbuilding industries to give preferential appointment to youths from junior day technical schools and secondary schools, and to make provision for their apprentices to continue their technical education on two, or, if possible, three, half-days per week in the institutions provided by the local education authorities.

4. That the employers' associations in connection with engineering, shipbuilding, and ship-repairing on the North-East Coast be asked to appoint the Institution as their representatives to act in a consultative capacity with the local education authorities for the development of apprentice training in technical education.

Pre-Apprenticeship Education.

Definition of Apprentice.—The first important point that arose in the discussion was the definition of an apprentice, and we desire to make it quite clear at the outset that our recommendations have no reference to those youths who pass direct, or after a period in works, from good secondary schools to a full university course, and subsequently enter the works as pupils.

The second point was the suggestion that the directed education of prospective apprentices might be given in the top classes of the elementary schools. Your committee are strongly of opinion that the special organisation afforded by junior day technical schools is better educationally and economically, and that elementary schools should be used for this purpose only as a last resource.

Junior Day Technical Schools.—After considerable discussion your committee agreed that prospective shipbuilding and engineering apprentices should be drafted from the ordinary classes of the public elementary school into suitable schools providing education, other than elementary, in which the prospective apprentices would receive a three years' course of directed preparatory education before beginning their apprenticeship, and that, wherever possible, the place of this further education would be a junior day technical school.

Aim of Junior Day Technical Schools.—The aim of the junior day technical school is to continue the general education of the pupil upon the broad basis of the elementary school, combined with the direct preparation for the vocation by which he is to earn his livelihood, so that the boy may begin his apprenticeship intelligently and without waste of time. During the three years between leaving the elementary school and becoming apprenticed the groundwork of all the preliminary technical subjects will be well laid, so that the pupil will be able to continue his studies during his apprenticeship, with much greater facility than would otherwise be the case.

Age of Admission.—The age of admission or transfer from the elementary school to junior day technical schools should be from 12 to 13 years of age, so that the three years' course of instruction should be completed before the boy begins his apprenticeship at 15 to 16 years of age.

Curriculum.—The curriculum includes:—

Mathematics and geometry.
Experimental mechanics.
Elementary science (physics and chemistry).
English subjects (including economic history and geography).
Machine drawing—suitable for—
(*a*) Those to be engineering apprentices.
(*b*) Those to be shipbuilding apprentices.
Manual training in wood and metal.
Practical work in the laboratory in all suitable subjects.

The curriculum also provides for the continuance of the moral and intellectual education given in the elementary schools, and provision is also made for reasonable recreation, physical exercises, and organised games, and the encouragement of a corporate life amongst the students.

Teaching Staff.—A reasonable proportion of the teachers in the junior day technical schools will have had practical trade experience in engineering and shipbuilding; though this does not mean that any attempt to teach the trades will be made. It is a recognition of the desirability of the foundations being laid by persons having some knowledge of the superstructure.

Boys from Secondary Schools.—Boys from secondary schools who become ordinary apprentices at about 16 years of age will take their place in the system to be described in the further part of this report dealing with "Education of Youths during their Apprenticeship." It is recognised that a good secondary school must provide a general education with such instruction in specific subjects that a boy on leaving school at about 16 years of age will enter naturally into the course at the point suited to his attainments.

General Education.—It is essential that during this period character should be formed, habits of industry inculcated, culture developed, and the sense of citizenship be implanted, so that the boy on starting his apprenticeship shall aim strenuously at becoming a good workman, at fitting himself for more and more responsible work, and at developing a sound citizenship.

Advisory Committee.—We record here our opinion that in connection with junior day technical schools there should be representatives of employers and employees associated with the management in a consultative capacity, so that a true proportion shall be maintained between the academic and vocational sides of the education.

Maintenance during School Life.—Further facilities should be provided by the local education authorities for the maintenance during the third year of the course, and possibly also during the second year, of necessitous but promising boys.

Regulation of Efflux of Pupils to Works.—If junior technical schools are to be established and maintained by the education authorities, it is essential for their success that employers should give preferential appointment to those youths on passing out of the schools, and the periods of efflux of those pupils must be arranged to suit the requirements of the district. The necessary arrangements for this would naturally be one of the functions of the advisory committee mentioned above.

Mode of Appointment of Apprentices.—To secure this preferential appointment the whole system of the selection of apprentices must be radically changed.

It is urgently necessary that nepotism in this connection, undoubtedly existent, should be eradicated. The selection of apprentices should be made by a competent member of the works administrative staff, acting in close consultation with the head master of the junior day technical schools. Official labour exchanges in this connection are of infinitely less importance than the clear concept of the employer as to his necessities and the intimate knowledge of the head master as to the abilities of his pupils to meet those necessities.

The Product of the Day Junior Technical School.—A full and generous provision of junior day technical schools for the North-East Coast would provide for the day education of a very large number of boys, who would have received a sound training from the age of 12½ years (approximately) to the age of apprenticeship in mathematics, mechanics, science, mechanical drawing, English and in the working of wood and metal. The annual draft of these boys into the works should, in a very few years, produce a marked rise in the general intelligence and potentialities of the workmen, and this conclusion becomes more apparent when it is borne in mind that it is proposed to build on this suitable preparatory

* "The Education of Youths before and during their Apprenticeship," by V. A. Mundella.

education—without break or delay—during the years of apprenticeship, as described in the following sections.

Education of Selected Youths during Apprenticeship.

Selection of Exceptional Boys.—Foremen and Higher Officers.—The large number of well-trained boys emerging from the junior day technical schools will be joined by a comparatively small number of boys entering upon their apprenticeship at about 16 years of age direct from the secondary schools, and of this total there will be a small percentage with exceptional ability, solidity of character, and general promise. Your committee propose that the education of these exceptional youths should be on different lines from those of the general body of apprentices, because it is from the comparatively few youths of exceptional ability and sterling character that the future foremen and higher officers of industry will emerge in greater proportion. Your committee assert with every confidence that it would be a sound business proposition for employers to have a number of selected youths in strenuous preparation for the middle to higher positions in the industries.

Education of Exceptional Boys Half-time.—It is proposed that these youths of exceptional promise should be engaged half of each week as apprentices in the works and half-time as students in the local technical college, where they would receive technical education in continuation of that received at the junior technical school and proceeding to a much higher standard. The curriculum should include also sound instruction in one foreign modern language as well as in English.

Second Selection of Youths. Scholarships and Maintenance Grants.—This education would continue for two years, that is, from about 16 to 18 years of age, when a second selection would be made from these exceptional boys at the age of 18 years. Those selected the second time must have shown all that is implied in "staying power," character and work, and should pass direct to the university for the full engineering or naval architecture degree courses. It is not anticipated that the number so selected will be more than a very small percentage of the total number of boys entering the industries from the junior technical schools, and it should be incumbent upon the education authorities or the State to provide scholarships and maintenance grants, so that the poorest boy may have a straight road from the elementary school to the completion of his university career, freed from the anxiety of providing ways and means.

Education during Apprenticeship of those Youths not Selected for Special Treatment.

Part-time Day Continuation Classes.—The selected boys having been withdrawn from those passing from the junior day technical schools to the works, the remainder, a large percentage of the total number, must continue their education without break during apprenticeship, and under such conditions as will enable this to be done without undue drain upon their energies and vitality. Your committee approve the council's recommendation that these youths should be liberated for at least two, and, if possible, three, half-days a week for the purpose of their technical education. In fact this change is foreshadowed as compulsory in the forthcoming Bill for the reform of our educational system.

Organisation in the Works.—A scheme for providing attendance for education on three half-days per week would involve a minimum absence from work of 10½ hours per week, and a maximum of 12 hours per week. Your committee have considered the question of possible disorganisation in the works consequent upon the arrangement, but they are of opinion that—as the boys will not be absent all at one time—the difficulties, though real, are not insurmountable.

Payment of Full Wages.—It is an essential feature of this scheme that attendance at part-time day continuation classes be regarded as part of the apprenticeship, and that there should be no reduction in wages on account of such attendance.

Curriculum.—The curriculum should be a continuance of that of the junior day technical school, with modifications, and should be on broad lines, such as is now being developed in the best types of evening continuation classes.

Duration of the Course.—It is recognised that compulsory attendance at these part-time day continuation classes should cease when the apprentice reaches about 18 years of age, but it is anticipated that some of them will be well qualified and anxious to continue their studies at selected advanced evening technical classes, which the local colleges will be anxious to conduct, having been freed from the necessity of providing for the large number of junior evening technical courses.

Transfer of Boys.—Your committee recognise that mistakes may be made in the selection of the exceptional boys at the two periods heretofore mentioned, but if a selected boy be found to be wanting either in ability or character he can be transferred at once to his natural place in the part-time day continuation course. If, on the contrary, a boy develops late and is not in the group of those selected at 16 years for half-time day instruction, then it will be equally easy to transfer him into his rightful position on proof of his ability to profit by the higher course.

Tuition in Works.—For the full development of the mechanical ability of the apprentice it is imperative that employers should provide definite practical instruction by expert craftsmen in the shops, and that this instruction should be continued throughout the whole of the apprenticeship. Your committee are unanimous in expressing their belief that the extra expense involved both in this arrangement and in the absence of apprentices during class hours will be returned to the employers, in a far higher degree, on the one hand by the greater skill of the workman, and on the other hand in the broader mental outlook and initiative of the individual.

Reports to Employers.—The employers and local education authorities must work in close harmony, and the latter must present periodical reports setting out the attendance, diligence, and progress of the student, and the disciplinary forces of the employers must be available in the early stages of backsliding. Any student showing continued lack of interest or application should, after careful investigation as to the cause of his failure, forfeit the facilities under the scheme.

Deputation to the Board of Education.

Our attention has been called to certain of the present regulations of the Board of Education for junior day technical schools and other courses which we consider are not in full sympathy with what should be the ideal aims of such schools and courses, and we recommend that a deputation representing the Institution be appointed to urge the Board, by interview with the President, to recognise the importance of a generous provision of these schools and of day apprentice classes in this district; and, in particular, to request that:—

1. The schools should be regarded as a distinct type of higher school, in no sense inferior to a secondary school, to which boys can enter direct from the elementary schools at 12 to 13 years of age for a full-time three years' course of directed preparatory education before beginning their apprenticeship;

2. The same freedom and financial assistance should be given to them as to secondary schools, under similar regulations;

3. The education given in them should be regarded as directly preparatory to the half-time continuation classes organised for the more promising boys from 16 to 18 years in the local technical college, just as the continuation classes themselves should be recognised as preparatory to the university or higher technical courses from 18 to 21 years.

Local Education Authorities.—In presenting this report to the council we urge most strongly that now is the time to press upon the local education authorities the consideration of this scheme, with a view to its being put into operation at the earliest possible moment. The best boys, now in the upper standards of the elementary schools, who have determined to enter in due course either the engineering or shipbuilding industry need to begin their three years' course of instruction in the junior day technical schools at once, as it will be nearly three years from the date of starting before they will enter the works as apprentices.

In conclusion, we agree that the Institution should act as representative of the employers' associations in connection with engineering, shipbuilding and ship-repairing on the North-East Coast in a consultative capacity with the local education authorities for the development of apprentice training in technical education.

Recommendations.

1. That the North-East Coast Institution of Engineers and Shipbuilders be appointed by the employers' associations in connection with engineering, shipbuilding and ship-repairing on the North-East Coast as their representatives, to act in a consultative capacity with the local education authorities for the development of apprentice training in technical education.

2. That prospective engineering and shipbuilding apprentices be drafted at 12 to 13 years of age to junior day technical schools for a three years' course of general education, including, amongst other subjects, mathematics, mechanics, machine drawing and manual training. Provision should be made also in these schools for the continuance of moral and intellectual training, as well as physical exercises, organised games, and the encouragement of corporate life.

3. That an advisory committee of representatives of the North-East Coast Institution and of employers and employees be associated with the management of these schools in a consultative capacity.

4. That employers give preferential appointment to these youths on passing out of these schools, and that in future the selection of apprentices be a function of a member of the administrative staff of the works, acting in close consultation with the head masters of the junior day technical schools.

That the periods of efflux of these boys be arranged to suit the requirements of the district.

5. That a selection (a small percentage) be made from these boys of those showing exceptional ability, solidity of character, and general promise at the beginning of the apprenticeship, and that they spend half the week in the works and half in the local technical college, in which they would receive a special two years' course of technical education. From these youths, it is expected, would be drawn the future foremen and higher officers of the industries.

6. That a second selection be made from these exceptional boys on the completion of the two years' course (see 5) and that these should pass direct to the university for the full engineering or naval architecture degree courses.

7. That the local education authorities or the State provide scholarships and maintenance grants, so that the poorest boy may have the full course from the elementary school to the completion of the university course without financial anxiety.

8. That the remainder of the boys (a large percentage) passing into the works as ordinary apprentices (not selected as in recommendation 5) should be liberated from the works for at least two half-days a week, and, if possible, three, for the purpose of attending part-time day continuation classes. That attendance at these classes be compulsory up to 18 years of age, and the time so spent be regarded as part of the apprenticeship, with no reduction in wages.

9. That definite practical instruction be given to all apprentices by expert craftsmen in the shops throughout the whole of the apprenticeship.

10. That suitable arrangements be made:—

(a) For the transfer of apprentices from part-time to half-time, and *vice versa*, on due cause being shown;

(b) For the disciplinary forces of the employers to be available in the schools in the early stages of backsliding;

(c) For the forfeit of the facilities provided under the scheme in case of continued failure of the apprentice to appreciate the advantages.

11. That in view of the near reform of our educational system, and the foreshadowing of compulsory part-time day continuation classes to 18 years of age, and in view also of the fact that local education authorities are now considering their educational programme after the war, we recommend the council, if this report be adopted, to press upon the local authorities the consideration of this scheme, with a view to its being put into operation at the earliest possible moment.

12. That a deputation from the Institution interview the President of the Board of Education to urge the importance of a generous provision of junior day technical schools and of day apprentice classes, accompanied by greater financial aid for their maintenance and by a revision of the regulations governing their management.

For and on behalf of the committee,

We have the honour to be, gentlemen,

Your obedient servants,

GERALD STONEY.
E. W. FRASER-SMITH.

May 18, 1917.

The above report has been submitted to and considered by the following employers' associations:—

The North-East Coast Engineering Trades Employers' Association.
The North-East Coast Ship-Repairers' Association.
The Tees and Hartlepool Shipbuilders' Association.
The Tyne Shipbuilders' Association.
The Wear Shipbuilders' Association.

The last-named association is in full sympathy with the objects aimed at, and the others generally approve of the Institution's scheme.

All the associations appoint the Institution to act as their representative in a consultative capacity with the local education authorities for the development of apprentices' training in technical education.

TAR OIL FUEL AND DIESEL ENGINES.*

By GEOFFREY PORTER, A.M.Inst.C.E.

(*Concluded from page* 78.)

I HAVE been particularly interested in examining indicator cards of engines burning residual petroleum oil, tar oil alone, and tar oil with the addition of a pilot jet of residual petroleum oil. More especially I desired to ascertain the conditions of temperatures in the cylinders, and to investigate the statement often made to me that the use of tar oil produces greater temperatures than does the use of a residual petroleum fuel oil. I agree that a higher temperature does result, but the increase is not of high value when allowance has been made for the slower burning property of tar oil by advancing the fuel admission. The question of excessive increase of temperature seems to be, as one might anticipate, bound up with valve setting.

Mr. Still, Mr. Prentice and Mr. Strickland have been exceedingly kind in sending me indicator cards taken from the engines under their control. My only disappointment in this connection is that the conditions of engine loading under which the cards were taken were not more closely in agreement. It would be unreasonable in these days to ask engineers to carry out tests or to specially adjust their engines for the purposes of the writer of a paper such as this. But I have the satisfaction of knowing that the cards represent actual running conditions and are therefore possibly more valuable than they would have been had they been taken after careful preparation.

The figures quoted later do not pretend to great accuracy. In several particulars it has been necessary to make assumptions, such as the value of clearance volumes and initial temperatures. The assumptions were made on similar lines for each engine, and the figures serve for comparative purposes.

The starting cards I have been able to obtain appear to be normal; I have not detected any difference of consequence between such cards taken from engines running on the fuels mentioned. In the engine fitted with pilot jet ignition gear under my own charge sudden pressure increases occur occasionally at starting. Though I have made many attempts to record one of these irregularities I have so far been unsuccessful. Abnormal starting pressures can be manufactured easily enough by feeding paraffin oil to the air valves, but an artificial condition at starting does not lead to results of actual value.

Nearly all the cards in my possession, taken at fairly high fractions of full load, are of good shape. I believe that all of us who have used tar oil, with or without pilot jet ignition gear, have found it necessary to advance the fuel admission, the setting for residual petroleum oil being generally too late for the slower-burning tar oil. Some of the earlier cards taken by myself were of a very indifferent appearance, showing late admission and late combustion, conditions that were confirmed when the cards were worked out. In general a card taken from an engine using tar oil with pilot jet ignition is not so

* Paper read before the Diesel Engine Users' Association, on Thursday, 24th May, 1917.

nicely shaped as a card taken with residual petroleum alone, or with tar oil alone as fuel. The prior ignition of the pilot jet produces a "peaked" admission line in comparison with the regular, slightly drooping curve which denotes combustion at constant pressure.

A few figures obtained by calculation from cards I have taken or received from other engineers may be of interest. Incidentally I should like to say that a very interesting paper might be read on the subject of indicator diagrams taken under the various conditions arising from the use of fuels other than residual petroleum oils.

1. A set of cards from a four-cylinder, 200-brake horse-power engine driving a 125-kw. direct-current dynamo, using residual petroleum as fuel, gave the following particulars :—

Cylinder.	Indicated Horse-power.	M.E.P.	Maximum Temperature F. abs.	Temperature at Exhaust F. abs.
		lb.		
1	48.5	77.0	2,560	1,745
2	47.1	74.8	2,580	1,658
3	53.7	85.3	3,010	1,745
4	51.3	81.5	2,799	1,865
—	Total 200.6	average 79.6	average 2,737	average 1,753

On entering the corresponding figures for a number of points on the diagram in a theta-phi chart the customary curve appeared to be of a tolerably good shape.

The engine was indicated at a load equivalent to 77.4 per cent. of full load. The engine was running under ordinary conditions at the time, no care being taken to adjust valve settings, &c. The cylinders are not quite evenly loaded, the maximum difference being about 11 per cent.

The next set of figures relate to cards taken from the same engine when burning tar oil with a pilot ignition jet of petroleum residual oil amounting to 12 per cent. of the weight of tar oil. The generator loading was 83.6 per cent. of the normal full load rating, i.e., 8 per cent. in excess of the load in the previous example.

The diagrams yield the following particulars :—

Cylinder.	Indicated Horse-power.	M.E.P.	Maximum Temperature F. abs.	Temperature at Exhaust F. abs.
		lb.		
1	56.1	85.4	2,860	1,575
2	59.4	90.5	2,875	1,805
3	61.1	93.1	3,048	1,965
4	53.8	82.0	2,805	1,741
—	Total 230.4	average 87.75	average 2,897	average 1,771

The corresponding temperature-entropy diagram is moderately good. The temperature stated at exhaust for No. 1 cylinder is, I think, too low, probably due to an error in measurement. Neglecting this temperature, the average temperature at exhaust opening is 1,837 deg. F. absolute. Taking into consideration the difference in the engine loading, neither maximum nor exhaust temperatures appear to differ much for either class of fuel oil.

These results were worked out from cards taken from the engine in which I am interested personally.

Mr. Prentice has sent me a set of cards taken from an engine at Felixstowe. These cards interested me very much, as tar oil is used as fuel without the assistance of a pilot ignition jet. Beyond starting the engine on residual petroleum oil the tar oil is relied upon solely. The load factor of this engine is so good that this course can be adopted safely. It is conceded generally that tar oil used alone is satisfactory when the engine is loaded to 75 per cent. of normal full load rating and upwards. I have been able to corroborate this fact on my own engine, but its running conditions do not permit safe or satisfactory operation without the pilot jet.

Mr. Prentice's cards refer to the same engine using tar oil in one case and residual petroleum in the other. Unfortunately only one card for each condition is sufficiently legible to enable any results to be calculated. The engine dimensions are : three cylinders, 14½-in. diameter by 22½-in. stroke, at 190 r.p.m.

The following figures give the results obtained from one card of each set :—

Fuel—Tar Oil alone ; loading equal to 91 per cent. of Normal Rated Full Load :

Indicated Horse-power.	M.E.P.	Maximum Temperature F. abs.	Exhaust Temperature F. abs.
85.6	101.25	3,105	2,055

Fuel—Residual Petroleum Oil ; Loading—85 per cent. of Normal Full Load :—

Indicated Horse-power.	M.E.P.	Maximum Temperature F. abs.	Exhaust Temperature F. abs.
78.8	93.1	3,095	2,210

The card taken with residual petroleum fuel oil, unfortunately, shows that combustion is taking place almost down to exhaust point, so the results are not strictly comparable. For this reason I should have been glad to have been able to work out the companion cards. The tar-oil card has a beautiful shape and would adorn a text-book.

I have also had the opportunity to work out two complete sets of cards given me by Mr. Still. They were taken from the same engine, burning tar oil alone in one instance and tar oil with a pilot jet of residual petroleum in the other.

The engine dimensions are : 300 brake-horse power ; three cylinders ; 26-in. stroke; 17-in. diameter pistons ; 170 r.p.m.

I obtained the following figures :—

Fuel—Tar Oil only (Class of Oil as sample "C 1") :—

Cylinder.	Indicated Horse-power.	M.E.P.	Maximum Temperature F. abs.	Temperature at Exhaust F. abs.
1	108	85.9	2,705	1,610
2	106	84.3	2,830	1,985
3	106	84.5	2,625	2,080

The cylinders are very evenly loaded. This is a detail more easily regulated when fuel is supplied from a central distributor, as with this engine, than with engines where each cylinder is fed from a number of pumps driven by the same mechanism.

The cards when using a *pilot jet* gave the following particulars :—

Cylinder.	Indicated Horse-power.	M.E.P.	Maximum Temperature F. abs.	Temperature at Exhaust F. abs.
1	114	90.3	2,815	1,755
2	111	88.2	2,826	2,050
3	109	86.3	2,725	2,410

The loading of the engine was the same for each set of cards, viz., 78.3 per cent. of the rated normal full load.

The results obtained with the pilot jet ignition show a higher mean effective pressure by 4 per cent., taking the mean for the three cylinders in each instance ; while the average maximum temperature is 2.5 per cent. higher for the second set of cards. This is to be anticipated, owing to the greater quantity of fuel injected into the cylinders when using the pilot jet, but, naturally, the efficiency of the engine is slightly reduced. This effect can only be seen definitely by comparing the results obtained from Mr. Still's engine, because the other two engines were not run on the same loads when indicated with each fuel oil.

In the second set of figures from Mr. Still's engines the comparison of temperatures cannot be made as exactly as could be wished, because the third cylinder in the second series shows evidence of late combustion to the end of the stroke.

I judge by the above figures that the use of tar oil increases the temperatures to a slight extent, but not excessively unless the valve settings are unsuitable for the quality of the tar oil.

I will now pass on to survey as briefly as possible the operating effects of the use of tar oil. My own experience has been with an engine equipped with Messrs. Mirrlees, Bickerton and Day's pilot jet ignition gear, and most of my remarks will refer to this engine. I hope that members who are using tar oil under other conditions will take part in the discussion on this paper and will give us the benefit of their own experiences.

The *ignition gear* was so fully described in Mr. Day's paper on "Tars and Tar Oils as Fuel for Diesel Engines," read before the Diesel Engine Users' Association on January 19, 1916, that a further description is unnecessary here. A note or two may be instructive. The tar oil supply is delivered by the main fuel pump to the cylinders under the control of the governor. The ignition oil is independently supplied but is not under control of the governor. The quantity of ignition oil is a fixed amount at all engine loads. The ideal quantity is 5 per cent. at full load. In practice I have not been able to reduce the quantity to so low a figure, probably owing to the very considerable wear in the engine after 5½ years of hard work. I shall refer to this point later. The quantity of oil delivered by the ignition pump is set by an arrangement, which permits the same adjustment to be given to each pump, each cylinder having its own ignition pump. The pump suction valve and stem are operated by a tappet, and the adjustment is made by setting the clearance between the stem and the tappet in a manner similar to that adopted in setting fuel pump clearances. The limits of the adjustment lie between 0.01 in. and 0.014 in. When the clearance between tappet and valve stem is at the latter dimension the maximum quantity of ignition oil is delivered ; when the clearance is 0.1 in. the minimum quantity for steady combustion is admitted to the cylinder. The adjustment can be carried out while the engine is at work, but the operation is rather delicate and requires a good deal of care. In the first instance, after fitting the gear, the pumps are set to the full stroke to ensure certain firing, and the clearance is then reduced carefully to the lowest possible dimensions. As the ignition pump is not controlled by the governor it is advisable to set the governor to keep the engine speed, if anything, on the low side, as the engine may "run away" when the load is thrown off suddenly. The smaller the quantity of ignition oil used the less probable is this condition. I think that the provision of some electrically controlled safeguard in connection with the ignition oil supply would be a desirable feature to adopt. In starting, the engine invariably runs out 20 to 30 revolutions above normal speed. The point is worth consideration, for I have run the engine on 4 per cent. of normal full load on the fuel supplied by the ignition pumps alone when set to deliver their maximum quantity.

A little trouble may occur with air lock in the pumps, especially when first put to work, and again after being opened up for inspection. An air vent is provided for the purpose of discharging air ; by using this and by manipulating the nuts which keep the discharge valves in position, excess air is easily got rid of. The pumps can be primed under gravity head when standing at bottom centre. After discovering the correct method to adopt I have not experienced any further trouble with air lock.

There is no special indication when a pump ceases to act. If the engine load is in the neighbourhood of 75 per cent. of full load, one does not notice anything ; but if the load on the engine is less than that figure the switchboard instruments indicate the fact at once. With a little experience one quickly ascertains which pump is the culprit. One quickly accommodates oneself to the new conditions.

In fitting these pumps too much care cannot be taken. Fitted studs and steady pins should be used to preclude the possibility of any movement of the pump body. The adjustments are so fine that even a little shake will affect the oil delivery.

In the ordinary course of running the engine (driving a direct-current dynamo direct-coupled) I find the speed control by the governor to be as satisfactory when using tar oil as when burning residual petroleum oil. Impulses are regular ; it is seldom that a cylinder "misses" ; and one would not be aware that a change of fuel has been made. The engine runs well even on $\frac{1}{10}$th load. I shall be interested to hear from our alternating-current members if they are equally satisfied in this respect. It has been suggested that surging of oil may occur in the ignition pump suction piping and that the provision of a non-return valve in the suction connection would be an advantage. Personally, I have not found a need for such an arrangement, but I may be particularly fortunate. A provision of the kind is made in the ignition oil delivery passage in the fuel valve casing by the insertion of "displacer plugs." I have run the engine with and without them and have noticed no difference in operation. But I have heard that the device is necessary in installations where alternators must be operated in parallel with each other.

Beyond a broken delivery valve spring I have had no trouble with the ignition pumps and have had no occasion to renew any parts. The whole arrangement of the gear is very neat and unobtrusive.

Before commencing the use of tar oil one or two adjustments must be made. In speaking of indicator diagrams I pointed out that an earlier fuel admission is necessary owing to the slower burning properties of the oil as compared with residual petroleum oil. I think the amount of the advance depends on the quality of the fuel. In my own experience I find an advance of about 1 deg. on the crank circle suffices. Similarly the closing of the needle valve needs a rather earlier adjustment. The only definite method to adopt is that of trial and error. As with residual petroleum oil, the condition of the colour of the exhaust is a guide to correct timing. I have had no difficulty in obtaining colourless exhaust at all loads with injection pressures of the same magnitude for tar oil as for residual petroleum oil. When attempting to use tar oil without ignition gear I found it necessary to reduce the injection pressure to a large extent in order to obtain satisfactory operation. Those engineers who use tar oil as the sole fuel have also found the reduction of the injection pressure essential for steady operation.

Another important point to consider is the compression pressure in the cylinders at no load. This pressure should not be less than 480 lb. per square inch. Below this figure both the ignition of the tar oil and of the residual petroleum oil may be uncertain ; and even if regular ignition is obtained combustion may be incomplete, leading to smoke and high exhaust temperatures. In an old engine that has done much work the wear of crank-pin brasses, cylinder liners, &c., all contribute to the loss of compression. The engine in which I am interested had been at work for a period of 14,000 running hours before being adapted to tar oil fuel. Nevertheless the engine has done consistently good service, using tar oil, for the past nine months, in April last being at work at 65 per cent. of full load (average) for 497 hours, or 16½ hours per diem.

Mr. Prentice has also obtained very consistent working with the engine he is operating with tar oil without a pilot jet. He informs me that the engine had been operated for 2,250 working hours at seven-eighths of full load during nine months, or about 8½ hours a day.

Judging by my own experience I think it very desirable to fit relief valves to the cylinders when using tar oil. The contrary opinion is often expressed. Increases of pressure do occasionally occur at starting, and it is essential, in my opinion, to take all reasonable steps to avoid adding to the already high stresses in the engine parts. The relief valves I now speak of are set to lift at 750 lb. per square inch. In the event of anumber of "misses" causing an accumulation of fuel on the piston head, and this accumulation suddenly firing, very considerable excess pressures may arise. It is improbable that any relief valve will prevent an explosion, but it will give useful warnings and will take care of all minor pressure troubles.

It is quite impossible to speak exhaustively of every part of the engine—time does not permit. No doubt the appearance of pistons, valves, &c., will be thoroughly discussed later on. I will content myself with saying that pistons become very dirty ; that the rings become fast in their grooves and should be examined at three months' intervals. The time elapsing between examinations of course depends upon the work done by the engine. The exhaust valves give no trouble. They are

cleaned and ground in at intervals of 250 running hours. Only once have I seen really heavy pitting, viz., after extending the running period to 360 hours. They were then very dirty and very heavily pitted. I am still using the original exhaust valves supplied with the engines five and a half years ago.

Air valves, needle valves and seatings, and flame plates, require no comment. The fuel pumps are rather more troublesome than formerly owing to the greater amount of sludge found in them. The lower viscosity of the tar oil also renders it more difficult to maintain the plunger glands tight than was the case when using residual petroleum oil.

I now come to the pulverisers. Here we have endless trouble owing to the choking of the cone grooves and rings. Frequently also the passages in the fuel valve casing become choked. The deposit collects rapidly; under the conditions I am familiar with, the deposit must be removed after 50-60 hours' running at about 65 per cent. of full load. If the fraction of full load is greater the deposit forms more rapidly. This difficulty is very generally found by engineers using tar oil. All tar oils do not show it, and others do so in varying degrees. On some days the deposit is very slight, at other times very heavy; sometimes exceedingly hard, and again very soft. If one cylinder is more heavily loaded than others the corresponding pulveriser will be the foulest when examined. Mr. Squire, of Chelsea, has tested this by throwing a greater load on one cylinder than on the other two of an engine, and found that the pulverisers were proportionately affected. I have taken cards from the engine under my charge when the cylinders have been irregularly loaded and have found the pulveriser of the most heavily loaded cylinder to show the most deposit. Some engineers have told me that their pulverisers have choked in 12 hours and less. In some instances the deposit is normally so great that it is necessary to reduce the full load rating of the engine. In my own case the deposit has been less since the warm summer weather set in, and this inclines me to suppose some connection between the crystallisation of the oil in the storage tanks and the deposit in the pulverisers. The cause of the deposit is still obscure. It may be due to insufficient pulverisation, a defect that could be obviated by modifying the pulveriser in question, or by substituting a pulveriser of different design. Several engineers have got rid of deposits completely by adopting another pattern of pulveriser. A type which secures the pulverising of a film of oil appears to be satisfactory. Others have changed the number of rings, or have taken steps both to reduce and to increase the available area of the oil ways in the pulveriser. One wishes, however, to be in a position to adopt a pulveriser which shall be equally effective for all oils rather than to attempt to improve matters by a makeshift. On the other hand the source of the nuisance may lie in the oil. Naphthalene has been suggested to me as a probable cause. Some engineers have gone so far as to state that naphthalene is the actual cause. I should not care to be so definite at this stage. I am assured by a chemist of acknowledged merit that naphthalene cannot have the effects experienced. Moreover, though all tar oils contain some naphthalene, the oil used does not contain very much, and yet the deposits are often very heavy. The presence of incombustible matter in the oil could very well lead to the formation of nuclei at which oil films would adhere and ultimately carbonise and choke a passage. The deposit occurs in using all the oils whose physical properties are tabulated earlier in this paper, and none of these oils contains high percentages of incombustible matter. I collected a considerable quantity of this deposit from my own engine recently. On being gently heated the greater part dissolved quickly, leaving a small residue after filtering, the residue being, no doubt, an insoluble constituent of the oil. I assume this effect is not apparent in the pulveriser because the temperature is high and varies rapidly. In my own case the choking of pulverisers is merely a nuisance, for other engines are available when the engine burning tar oil is shut down to clean out pulverisers. No harmful effect has ever been observed. But for an engineer who cannot ring the changes on his plant the matter is something far more serious than a mere nuisance.

Another small point occurs to me from personal observation, and that is the sweeter running obtained by increasing the injection pressure at all loads by about 20 lb. per square inch. The "cadence" of the engine and the operation of the top gear are then very much more regular. No doubt pulverisation is improved, the impulses are more even, and the governor runs more steadily.

Finally, tar oil is very unpleasant to handle; it is very fluid. The standard of engine and engine-room cleanliness, and also of personal cleanliness, is much more difficult to maintain than was the case with residual petroleum oil. I fear that the filthy properties of the oil are inherent and must be borne with in a philosophical spirit in view of the commercial advantage accruing from its use.

I must now comment briefly upon fuel consumptions, financial results and kindred matters.

My own engine (fitted with pilot jet ignition gear) has provided the following results from September, 1916 to the end of April, 1917:—

Hours running	2,671.
Average load	58.5 per cent. of full load.
Weight of oil fuel per kilowatt-hour (tar oil and residual petroleum oil) ...	0.826 lb.
Petroleum oil as per cent. of tar oil	14.9 per cent. by weight.
Estimated saving by comparison with equivalent cost of petroleum oil ...	0.494*d.* per kilowatt-hour (in cash, 372*l.* 7*s.* 9*d.*).

On an investment of 160*l.* (the cost of fitting the gear) the return is a handsome one.

The following figures relate to fuel consumptions at various fractions of full load, and include both tar oil and the pilot jet oil:—

	Lb. per Kilowatt-hour.
At 34½ per cent. of full load	1.64
,, 42 ,, ,, ,,	1.02
,, 67½ ,, ,, ,,	0.70
,, 74 ,, ,, ,,	0.66

These figures are taken from the daily records. I have had no opportunity to carry out careful trials.

The next table states the percentage of petroleum oil to tar oil at various loads, in accordance with the adjustments adopted in the ignition oil pumps:—

	Per cent.
At 20-29 per cent. of full load	17.5
,, 40-49 ,, ,, ,, ...	16.4
,, 50-59 ,, ,, ,, ...	15.0
,, 60-69 ,, ,, ,, ...	13.9
,, 70-79 ,, ,, ,, ...	13.3

If these figures are plotted on squared paper a straight line results, as should be the case, and if the line is continued to ascertain the percentage at 100 per cent. of full load one finds 10.3 per cent. as the proportion of petroleum oil at that stage.

I have run the engine many times on lower proportions of petroleum oil, but found that firing was at times uncertain. Ultimately I fixed upon the proportions stated above.

In two instances within my knowledge the one percentage was finally adjusted to 8 per cent. on a nearly new engine, and the other at 11 per cent. (on two old and hard-worked engines). Mr. Day, in his paper already quoted, mentioned 5 per cent. as a probable proportion of petroleum oil. From what I have been able to gather from observation and from conversation and correspondence with other engineers, I am afraid 5 per cent. is only attainable under ideal conditions.

The figures given in the two tables below relate to a pair of exactly similar engines (under my control), the one burning residual petroleum oil, the other, tar oil with a pilot ignition jet.

The thermal results are a little curious, as higher efficiencies are obtained with the lower-grade oil, i.e., the oil of the lower calorific value. I assume the result has its origin in the fact that the residual petroleum oil we are now obtaining has a lower heating value than the oil obtained before the war broke out. This has been suspected by many engineers during recent months owing to the fuel consumption of their engines being consistently higher than was formerly the case. Members will agree that under present circumstances we are only too glad to get oil at all, and are willing to sacrifice heat units to the power to "carry on."

Fuel Oil—Residual Petroleum.

—	Running Plant Load Factor.	B.T.U. per Kw.-Hr.	Overall Thermal Efficiency.	Cost of Fuel, Pence per Kw.-Hr.
	Per cent.			*d.*
1	32.1	15,650	21.7	0.931
2	47.1	15,480	21.8	0.981
3	61.2	13,370	24.1	0.836

Fuel Oil—Tar Oil with Pilot Jet Ignition 10.3 *per cent. at Full Load.*

—	Running Plant Load Factor.	B.T.U. per Kw.-Hr.	Overall Thermal Efficiency.	Cost of Fuel, Pence per Kw.-Hr.
	Per cent.			*d.*
1	36.3	15,005	22.6	0.458
2	47.2	13,229	25.79	0.399
3	49.5	15,205	24.23	0.410
4	62.4	12,615	28.9	0.399

These figures are not the results of trials, but are taken from the daily records and are put forward as an example to indicate approximately the limits within which results may be expected to lie. They actually point to the fact that the tar-oil-plus-pilot-jet engine is better than the petroleum oil engine, not only in cost of working, but in efficiency also, the latter being a result one would not anticipate.

This paper will not be complete without a few figures giving the reductions in fuel cost in power stations whose engineers have been good enough to send me the information:—

1. Engines using pilot ignition gear:

(*a*) Reduction of fuel cost	12*l.* 10*s.* per week.
(*b*) ,, ,, ,,	0.35*d.* per kilowatt-hour.
(*c*) ,, ,, ,,	0.494*d.* per kilowatt-hour.

2. Engines burning tar oil without pilot jet gear:

(*d*) Reduction of fuel cost	0.26*d.* per kilowatt-hour.
(*e*) ,, ,, ,,	0.400*d.* per kilowatt-hour.

Owing to varying rates paid in different localities for tar oil and residual petroleum oil the above figures are not strictly comparative. All of them, however, show large reductions in fuel cost, and are, to those who have taken up this fuel question seriously, distinctly gratifying.

The estimate of the probable advantage put forward by Mr. Day in January, 1916, has proved to be a conservative one.

I have purposely refrained from saying much on the running of engines without the pilot jet ignition, as I have very little experience of that method of operation. I have been able to work my three engines without pilot ignition when they are loaded above 70 per cent. of full load. I am not able to guarantee so high a load factor for many hours consecutively, and I found that variations of load gave rise to very unsteady running. I therefore adopted the pilot ignition gear, which enables the engine adapted to operate steadily at all fractions of full load. I also attempted to operate with mixtures of tar oil and petroleum residue oil, obtaining fairly favourable results when using an even mixture of the two fuels. Difficulties arose in course of time, and I came to the conclusion that the method was a dangerous one.

With these remarks I will conclude. I hope I have been able to give a fairly general survey of the position as it now stands. I shall look forward to constructive criticism and rectification, where it is necessary, in the discussion. The subject is a most important one and cannot be too thoroughly thrashed out.

My grateful thanks are offered to those gentlemen who have given their time and trouble in abstracting information from their records. But for their kindness I should have had difficulty in preparing my remarks.

THE CARNEGIE COMPANY'S BLAST-FURNACES.—On June 19, says *The Iron Age*, the Carnegie Steel Company, Pittsburgh, had 50 blast-furnaces in operation and 9 idle. Some of the latter are banked, awaiting coke; others are idle for relining and repair, and will be started as soon as ready if coke can be secured.

ELECTRIC LIGHT UNDERTAKINGS IN PETROGRAD.—The city of Petrograd, under date of May 23, has taken over the Belgian Company for Electric Lighting, as well as the Helios Electricity Company, and the two concerns were to be worked for account of the city from that date. The St. Petersburg Company for Electric Lighting, the largest concern of the kind in the Russian capital, will not be taken over by the municipality, but transformed into a new limited company, in the share capital of which the cities of Petrograd and Moscow will be interested to the extent of 15 per cent. The latter development has been very unfavourably received in Germany, a fair amount of German capital being invested in the concern.

PAPER TUBES AND PAPER SACKS.—Paper tubes for liquids and gases are one of the novelties which the dearth of metals has helped to develop. Several kinds of these tubes have been tested by M. Rudeloff in the Materialprüfungsamt, as the report of this Institution for the year 1916 shows. According to the process of A. von Valois, the paper is rolled to the desired wall-thickness and diameter, and the seams are then glued together and coated. Tubes which had been kept full of water for weeks showed no swelling or loss of strength; they were not attacked by coal gas, either, and as they weigh only one-sixth of lead pipes and stand more than three times the bursting pressure, they may answer for gas and water distribution. The trouble is in the jointing; the joints are made by putting sleeves over the tubes and filling some cement into the annular space; so jointed, the pipes did not stand the internal pressures of unjointed sections, and frequently gave way at the joints. As regards external pressure, a strength of 28 kg. per square centimetre was found, which would be sufficient to admit of burying such paper pipes in the ground. Another type of tubes tested is the "pertinax"; in this case the paper is impregnated with synthetic resin and rolled under tension. The water tests of the pertinax tubes were not quite satisfactory. The tensile tests were made with strips cut from the tubes, and the wet material was found to be less strong than the dry material; as the moisture gained access through the cut edges, however, that test would not be conclusive. But there was also absorption of water by the material when closed tubes were filled with water and kept standing. The water absorption was particularly strong during the first hour, but had not stopped after 282 hours. As oil does not attack synthetic resin, however, small oil conduits might be made of pertinax paper, which can be shaped into tubes as small as 5 mm. diameter. Against that use is the low compression strength of the material (4.6 kg. per square centimetre), while the tensile strength of from 10 kg. to 18 kg. per square centimetre would suffice. The paper-yarn sacks for sand are a speciality of Messrs. Cassells and Co. The material has to be waterproof, *i.e.*, suitably impregnated so as to retain sufficient strength in the wet condition. Good results were obtained (according to the *Chemiker Zeitung*, 1917 page 56) by impregnating the dry paper-yarn at 50 deg. C. with a solution containing 80 grammes of glue, 1.5 grammes of tannin, and 1.5 grammes of sodium silicate of density 1.345. The tensile strength of strips of the dried material was 39.4 kg. per square centimetre untreated, and 45.7 treated; after 24 hours' soaking in water the figures were 26.4 kg. and 34.2 kg., and after redrying 41.2 kg. and 45.2 kg. per square centimetre. These figures apply to the warp; the weft figures were a little lower throughout. Favourable results were also realised with successive impregnations, first with cold basic aluminium formate, then with glue, and again with the formate. Mixtures of soap and glue did not answer.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

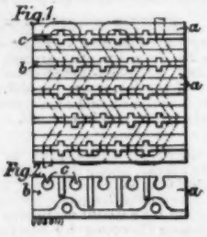
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

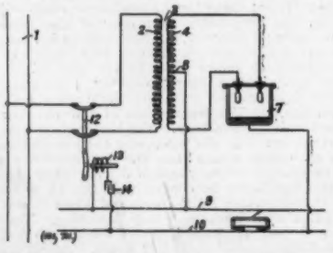
ELECTRICAL APPARATUS.

106,011. The Cable Accessories Company, Limited, and F. H. Reeves, Tividale, Tipton. Electric Heaters. (3 *Figs.*) June 15, 1916.—The invention relates to the type of electric heater which comprises a resistance member which is carried by a supporting medium which is in sections *a* of elongated form, such sections each having a longitudinal rib *b* and being adapted to be aggregated together by connecting bolts or members passing transversely through the sections. According to the present invention, in this type of heater the longitudinal ribs *b* are furnished with perforations *c*, notches, or the like, extending through the rib and adapted so to accommodate the resistance



medium that it is disposed in bights arranged substantially transversely to the length of the sections *a*. In the process of assembling the sections *a* are first disposed with their perforations or notches *c* in alignment, so that the transverse bights of resistance medium are straight, and afterwards, by endwise displacement of the sections *a*, the bights of resistance medium are caused to assume their zigzag form, in which operation they are thereby stretched or tensioned. The sections may be bolted or retained in the positions which they have thus assumed to maintain thereby the bights of resistance medium in their tensioned and zigzag formations. (*Accepted May* 16, 1917.)

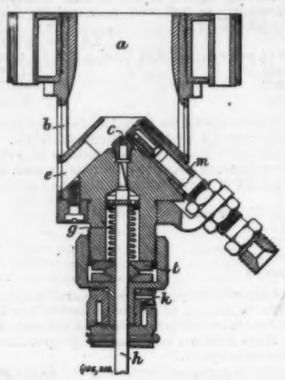
101,711. The British Westinghouse Electric and Manufacturing Company, Limited, Westminster. Electric Distribution. October 7, 1915.—This invention relates particularly to systems of electrical distribution in which a direct-current circuit is supplied with energy from an alternating-current circuit through a current-rectifying device. The object of the invention is to provide a system of the above-indicated character in which the supply of energy to the direct-current circuit may be interrupted, upon the occurrence of a short circuit or ground or other abnormal condition therein, without injury to the system or the apparatus associated therewith. According to the present invention, a circuit breaker is placed in the alternating-current circuit, the trip coil of which is energised from the direct-current circuit through a condenser. 1 is an alternating-current circuit from which current is supplied to the primary winding 2 of a



transformer, the terminals of the secondary winding 4 of which are respectively connected to the anodes of a vapour converter 7, and the middle or another suitable intermediate point of which is connected to one conductor 9 of an electric railway, the other conductor 10 of which is connected to the cathode of the vapour converter. The circuit 9—10 thus receives direct current through the transformer 3 and the converter 7. 12 is a circuit breaker employed between the alternating-current circuit 1 and the primary winding 2 of the transformer 3, and this circuit breaker is arranged to be tripped upon the occurrence of an abnormal condition in the direct-current railway circuit 9—10 that would tend to cause the current therein to exceed a predetermined limit. The tripping mechanism of the circuit breaker comprises an actuating coil 13, which is connected in series with a condenser 14 between the conductors 9—10 of the railway circuit. (*Accepted May* 23, 1917.)

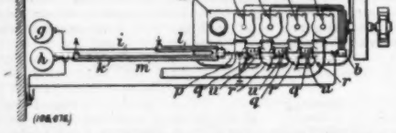
GAS ENGINES, PRODUCERS, HOLDERS, &c.

106,210. A. E. Berriman and The Daimler Company, Limited, Coventry. Carburettors. (2 *Figs.*) September 2, 1916.—The present invention relates to carburettors in which a small jet of air under pressure is employed for the purpose of atomising a jet of liquid fuel under pressure, the pressure in both cases being maintained by the pressure in the fuel tank. The invention consists in the combination of such a fuel jet and atomising device, with a valve controlling the fuel jet operatively connected with the air throttle, and adapted completely to close the jet when the air throttle is shut. The body of the carburettor is machined so as to form a mixing chamber *a*, into which air is admitted through radial ports *b*, while petrol enters through a central jet *c*. The admission of air is controlled by a ported sleeve surrounding the body of the carburettor and acting as an air throttle by opening or closing the air orifices. These consist of a number of simple apertures *b*, *b* and a number of tubular passages *c*. The liquid fuel issuing from the jet is controlled by a needle valve, which tends to close under the influence of a spring gland *g*, and is opened by a cam action when the spindle *h* is rotated; one of the co-operating cam surfaces *k* is connected



to a lever or pulley connected to a similar device on the air-throttle sleeve so that both sets of air passages and the jet is simultaneously controlled; while the jet is completely closed when the air throttle is shut. A screw gland *t* may be provided to prevent leakage at the point where the spindle of the needle valve issues from the body of the carburettor. In one of the tubular air passages there is fitted a tube *m*, the inner end of which is partially closed in such a way as to leave a small orifice pointing cross the axis of the fuel jet. (*Accepted May* 23, 1917.)

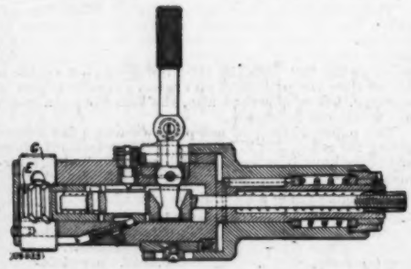
106,076. B. E. D. Kilburn, London. (*Sulzer Frères Société Anonyme, Winterthur, Switzerland.*) **Internal-Combustion Engines.** (1 *Fig.*) March 23, 1917.—This invention relates to apparatus for heating heavy or thick oil when used in internal-combustion engines. The primary feature of the apparatus, according to this invention, is that the fuel-supply pipe between the fuel-supply tank and the fuel pump is formed as a double pipe, through the outer annular space or jacket of which hot water flows. Preferably another portion or extension of the fuel pipe is so arranged that it is heated by the exhaust gases of the engine, as, for example, by the pipe being carried through one or more chambers through which the exhaust gases pass. *a* is a four-cylinder internal-combustion engine to which fuel is supplied by the fuel pump *b*, through four pipes, *c*, *d*, *e* and *f*. *g* and *h* are fuel tanks, it being assumed by way of example that the



engine works with two different kinds of fuel. The light or thinner oil is in the tank *g* and the heavier oil in the tank *h*. The fuel from the tanks *g* and *h* is carried to the fuel pump *b* through pipes *i*, *k* and *p*. According to this invention, the pipes *i* and *k* are surrounded by a second pipe or jacket *l* and *m* respectively, through which heated water can be passed. This water flows in the direction indicated by the arrows, first into the jacket *l* and then into the jacket *m*. The exhaust pipes lead into a common exhaust pipe or collector, and some or all of them are also connected by short pipes *u* through which the exhaust gases can be led in variable quantities by regulation of the valves *r*. In the branches *u* are coiled pipes *q* forming part of, or connected with, the fuel-supply pipe *p*, so that it is possible to raise the temperature of the fuel passing through the coils to any desired point. (*Accepted May* 16, 1917.)

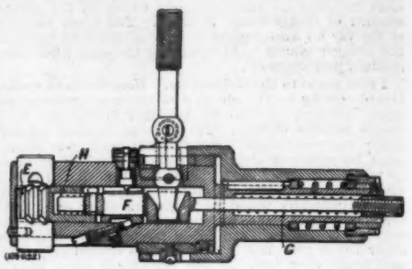
MACHINE AND OTHER TOOLS, SHAFTING, &c.

106,033. A. Herbert, Burford, Oxon, and A. H. Lloyd, Earlsdon, Coventry. Screw-Cutting Taps. (3 *Figs.*) August 16, 1916.—This invention relates to screw-cutting taps of the kind in which the chasers are expanded by the movement of a bolt or plunger in the stock. According to this invention,



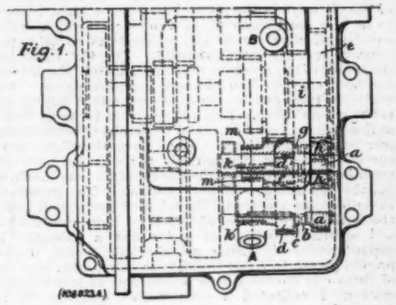
the plunger E is movable in two directions, that is to say, it can be twisted slightly as well as moved endwise, and the acting portion which engages the chasers C is formed with steps, so that by twisting it into its two positions the chasers can be expanded correctly for both the rough and finishing cuts. (*Accepted May* 16, 1917.)

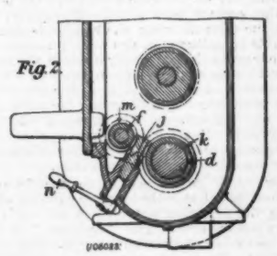
106,032. A. Herbert, Burford, Oxon, and A. H. Lloyd, Earlsdon, Coventry. Screw-Cutting Taps. (2 *Figs.*) August 16, 1916.—This invention relates to screw-cutting taps of the kind in which the chasers are expanded by means of a plunger which is moved endwise in the stock. Usually the plunger is made in two parts, E, F, coupled together, and a main spring G acts upon the major rear part F and a light spring H on the minor part E, the latter serving to prevent accidental disengagement, and there is some clearance allowed between the two plunger parts to permit of quick operation. According to this



invention, the light spring H is placed between the two plunger parts E so that it does not resist withdrawal of the plunger as a whole. The minor part E is solid, and, therefore, it can be made very much smaller than is the case where the plunger is mounted upon a rod or the like forming a portion of the major part, and preferably the adjustment acts upon the rear of the forward part and is therefore removed from the front, still further enabling the overall dimensions to be reduced if necessary. (*Accepted May* 16, 1917.)

106,023. A. Laidlar and George Richards and Co., Limited, Broadheath, near Manchester. Machine Tools. (2 *Figs.*) July 7, 1916.—This invention relates to machines for boring, facing, milling, drilling, tapping and like metal-cutting operations of the type in which the mandrel or spindle carrying the face-plate upon which the tool-holder is mounted is capable of vertical movements, and in which the tool-holder is capable of being continuously traversed across the face-plate. The invention comprises the incorporation within the gear-box usually located at the base of the machine, for giving the necessary speed changes for the face-plate spindle, of a reversing motion whereby forward and reverse driving of said spindle are conveniently effected from the one gear-box under the immediate control of the tool operator. The primary pinion *a* of the change-speed gear for the face-plate spindle is mounted freely upon the first motion shaft in the gear-box and is provided with clutch teeth *b* adapted to be engaged by teeth *c* upon a sliding spur wheel *d*, feather-





keyed upon said shaft. Thus when the sliding spur wheel *d* and primary pinion *a* are clutched together there is a direct drive from the first motion shaft through said primary pinion to the spur wheel *e*. The sliding spur wheel *d* meshes continuously with a broad-faced intermediate sliding spur wheel *f*, also having clutch teeth *g* and capable of being clutched to a pinion *h* which meshes with the same spur wheel *e* on the intermediate shaft *i* of the change-speed gear as the primary pinion *a*. When, therefore, said primary pinion is free or declutched, and the intermediate sliding spur wheel *f* is clutched to its pinion *h*, the gears in the gear-box are rotated in the reverse direction from the first motion shaft. The actuation of the two sliding spur wheels *d* and *f* is accomplished by a single pinion *j* disposed between and engaging circular racks *k*, *m* upon extensions of said wheels, so that the latter are moved simultaneously, but in opposite directions. The operating handle *n* for said actuating pinion *j* is upon the exterior of the gear-box in a position convenient for manipulation by the machine attendant. (See Fig. 2.) (*Accepted May* 16, 1917.)

THE EARNING OF GOODS WAGONS.—According to *The Railway Review*, Chicago, the average earning per day of goods wagons in the United States, in the last fiscal year ended June 30, 1916, was 2.91 dols. When a wagon is laid up for repairs there must be added to the actual expenditure of repairing the amount of 2.91 dols. per day for lost time, or 87.30 dols. per month.